8563

THE
THEORY
OF
COMETS
ILLUSTRATED,

In FOUR PARTS.

I. An ESSAY on the NATURAL HISTORY and PHILOSOPHY of COMETS; being the Subſtance of all that has been hitherto publiſhed on that Head.

4

II. TABLES, containing the ELEMENTS of the Theory of a COMET's MOTION, (in a PARABOLA or an ELLIPSIS) with their Nature and Uſe explained.

III. The Method of conſtructing the ORBIT of any COMET, and computing its Place therein; its Latitude and Longitude, as ſeen from the Earth or Sun; its Diſtance, Velocity, Magnitude, Length of Tail, and other Particulars relative thereto.

IV. The Method of delineating the *viſible Path* of a COMET in the Heavens, on the Surface of a *Celeſtial Globe*; and for drawing the Trajectory by Protraction with Scale and Compaſſes.

The whole adapted to, and exemplified in the *Orbit* of the COMET of the Year 1682, whoſe *Return* is now near at Hand.

By BENJAMIN MARTIN.

Syſtematis Mundani Compagem elegantiſſimam ita tandem pateſecit Newtonus, *& penitius perſpectandam dedit, ut nec ipſe, ſi nunc reviviſceret, Rex* Alphonſus *vel Simplicitem vel Harmoniæ Gratiam in ea deſideraret.*

COTES in Præf. ad Edit. ter. Princip.

LONDON:
Printed for the AUTHOR, at the Sign of the *Viſual-Glaſſes* and Glob
two Doors below *Crane-Court*, in *Fleet-Street*, 1757.

PREFACE.

IN the following Treatiſe I have endeavoured to illuſtrate the Theory of Comets, *ſo far as I judged any Thing of that Kind could be deſired or expected by the Public in general. For as the Time is drawing near, when that Part of Aſtronomy (which as yet is but dawning) may receive great Light and Improvement, or perhaps may be advanced to as great Perfection as it is capable of for two or three Ages to come; I concluded it would be very acceptable to the junior Students in that Science, to have the Theory of thoſe wonderful Motions illuſtrated by a practical Solution of the principal Problems relating thereto, and applied to that very Comet on which they will ſoon have an Opportunity of making their Obſervations, and proving the ſame by* Experiments.

To this Purpoſe I have premiſed as much concerning the natural Hiſtory and Philoſophy of Comets as I thought could be of any Uſe; for beſides, what Hevelius, Flamſted, Newton, Halley, *and* de la Caille *have ſaid on the Subject, there is nothing worth relating from others, and the Reader has here the Subſtance of all they have deliver'd, in Regard to this particular Head.*

As the Theory of Comets in the Writings of thoſe learned Authors, is chiefly ſpeculative and interwoven with ſuch Parts as are extremely difficult, I have ſelected that Part only which is uſeful and eaſy to any Reader that is but moderately verſed in Trigonometry; and to make him ready at Cometary Calculations, I have ſupplied him with all the neceſſary Tables, and ſhewn him the Procedure in every Part; he is therefore qualified by theſe Means to conſtruct the Orbit of any Comet *in the Catalogue, and to find its* Place, Latitude, Longitude, Diſtance, Magnitude, &c. *when they are in any Parts near the Sun.*

But as there are a great Number of curious Gentlemen (and Ladies too,) who may eaſily repreſent the viſible Path of a Comet on the Globe whenever it appears, and find it a moſt ſublime as well as pleaſant Amuſement, I have given proper Directions how to proceed in that Affair; and as many (not acquainted with the Stars,) may not be ſo ready at ſtretching a Thread over the Stars to find the Place of the Comet among them, I have contrived a Quadrant that will enable them to obſerve the Comet and put it on the Globe without Regard to the Stars at all, and that in three or four Minutes of Time; and which is uſed with the utmoſt Eaſe, as I can convince any Gentleman who ſhall apply to me on that Account. Therefore any Perſon poſſeſs'd of a Celeſtial Globe may, if he pleaſes, delineate with his own Hand the enſuing Comet's Orbit on the Surface of it; and thereby ſhew its apparent Place, Latitude, Longitude, Node, length of the Tail, &c.

Then as to the Method of drawing the real Trajectory of the Comet in the Heavens, I have ſhewn not only how that may be eaſily done by Protraction *with* Scale and Compaſſes, *but have enliven'd the Thing, by giving a Specimen of the Praxis adapted to the real Orbit of a Comet, and to that very Comet which will next ſalute their Sight.*

In the laſt Place I have given the Method of eſtimating the Velocity of a Comet and its Tail, inſtancing in that enormous and tremendous One of 1680. *In all other Reſpects the Print of the Comet I lately publiſh'd is ſufficient for the underſtanding any Thing here advanced, together with the Plate at the End of this Book. I have only to add, that if a* Mathematical Demonſtration *of any Propoſitions here advanced be required, the Reader may meet with it in my* Philoſophia Britannica, *which he may conſult at his Leiſure. And alſo that if a more accurate or perfect Procedure be required for defining the real Path of a Comet in a* Rectilineal, Parabolical, *or true* Elliptical *Trajectory, to be determined from* 4, 5, *or* 6 *Obſervations, either by the* Method of Interpolation, *or* Geometrical Inveſtigation, *it will be no diſagreeable Taſk, and will be readily perform'd, if I meet with proper Encouragement for what I have here done in theſe four firſt Eſſays.*

London, *June* 4, 1757.

AN ESSAY ON THE NATURAL HISTORY and PHILOSOPHY of COMETS.

PART I.

THE ancient *Egyptians* and *Chaldeans* (if we may credit *Diodorus Siculus)* by a long Courſe of Obſervations, were ſaid to be able to predict the Appearances of Comets; but ſince they are alſo ſaid by the Help of the ſame Arts to have prognoſticated Earthquakes and Tempeſts, it is paſt all Doubt, that their Knowledge in theſe Matters was the Reſult rather of meer aſtrological Calculation, than of any aſtronomical Theories of the celeſtial Motions: And the *Greeks*, who were the Conquerors of both thoſe People, ſcarce formed any other Sort of Learning amongſt them than this; ſo that it is to the *Greeks* themſelves as the Inventors (and eſpecially the great *Hipparchus)* that we owe the Aſtronomy we have, and which is now improved to ſuch a Height. But yet among the *Greeks* the Opinion of *Ariſtotle* (who would have Comets to be nothing elſe but ſublunary Vapours or airy Meteors) prevailed ſo far, that this moſt difficult Part of the aſtronomical Science lay altogether neglected; for nobody thought it worth their while to take notice of, or write about the wandering, uncertain Motions of what they eſteemed Vapours floating in the Æther; whence it came to paſs, that nothing certain concerning the Motion of Comets can be found tranſmitted from them to us *.

---

* Dr. *Halley*'s *Synopſis Aſtronomiæ Cometicæ.*

But to mention more particularly the Opinion of ſome of the moſt eminent Philoſophers among the Ancients concerning Comets, we ſhall firſt take notice of what *Ariſtotle* ſays in his firſt Book of Meteors, Chap. 6. where we find this Paſſage—Some of the *Italians*, called *Pythagoreans*, ſay, that a Comet is one of the Planets or wandering Stars, but that they do not appear unleſs after a long Time, and are ſeen but a ſmall Time, which happens alſo to the Planet *Mercury*.

Plutarch, in his third Book of philoſophical Opinions, Chap. 2. ſays —Some of the *Pythagoreans* ſay, that a Comet is a Star of the Number of thoſe which do not conſtantly appear in the Heavens, but in ſtated Times, having gone through a determinate Circuit, ariſe or appear again.

Seneca, Book 7. Chap. 3, of his Natural Queſtions, has this Paragraph—*Democritus* (the moſt ſubtil of all the Ancients) ſaid, that he ſuſpected that there were ſeveral *running Stars*, (by which he means the Comets) but that he neither determined their Number nor Names, not having yet rightly underſtood the Courſes of the Five Stars, (that is, the five *Planets*) except the *Sun* and the *Moon*.

Again, the ſame Author in the ſame Place ſays, that *Apollonius*, the *Myndian*, who was very ſkilful in natural Sciences, affirms, that the Comets were by the *Chaldeans* reckoned among the Planets: and had their Periods or Courſes like them.—Alſo that *Apollonius* uſed to ſay, that a Comet was a Star or celeſtial Body, as the Sun or Moon, but that he did not know its Courſe, becauſe it runs thro' higher Parts of the World, and then at laſt appears when it comes to the loweſt Part of its Courſe.

And *Seneca* himſelf, the moſt ſagacious of all the Ancients, and who wrote a Treatiſe expreſly concerning Comets, containing 32 Chapters, gives his Opinion of Comets in the following Words—I do not think a Comet to be ſudden Fire, *but one of the eternal Works of Nature.*—And again he ſays, that there ought to be a Connection (of Obſervations) of the former Riſes or Appearances of Comets, becauſe by reaſon of their ſeldom appearing, their Courſes cannot yet be underſtood, neither can it be diſcovered whether they return or not, or that they appear in Order at a ſtated Time. Thus has this Author hinted or pointed out the ſole and only Method by which this Queſtion can be ſolved.

But what ſhews the Penetration (I had almoſt ſaid, Preſcience) of this Author, in the higheſt Point of Light, is, the following remarkable Paſſage (I may properly call it a Prophecy) in the 25th Chapter of his Book of Comets.—"Why ſhould we wonder that the Nature of "Comets, ſo rare a Spectacle in the World, ſhould not yet be under- "ſtood, or their Courſes determined by aſtronomical Theories, when "they go to and return from ſuch prodigious Intervals of Place and "Time. It is not yet 1500 Years ſince the *Greeks* firſt numbered the "Stars and gave them Names; and even now there are many Nations "who know not the Reaſon of an Eclipſe of the Sun and Moon. "But a Time will come when thoſe Things which are now hid, will "at laſt be brought to light by Length of Time and the Diligence of "Poſterity. One Age is not ſufficient to make ſuch great Diſcoveries. "*A Time will come when thoſe who come after us will wonder that we were* "*ignorant of things ſo plain.*" And in the 26th Chapter he ſays— "*Somebody will ariſe in Futurity, who will demonſtrate which way the* "*Comets move; why they go ſo far from the reſt of the celeſtial Bodies;* "*how big, and what ſort of Bodies they are.*" All theſe Predictions have been accurately fulfilled and compleated in Sir *Iſaac Newton.*

Notwithſtanding, *Seneca* has ſo clearly diſcourſed on the Nature of Comets in that dark Age, yet few of the ſucceeding Aſtronomers were of his Opinion, for they generally eſteemed them as Meteors kindled in the Air, and deſigned as Preſages or unlucky Omens of ſome diſaſterous Cataſtrophe that was ſhortly to befal the People or Nations to whom they appeared. Nor did *Seneca* himſelf think fit to ſet down thoſe *Phænomena* of the *cometary Motions,* by which he was enabled to maintain his Opinion, nor the Times of thoſe Appearances which might have been of Uſe to Poſterity, in order to the determining theſe Things. And indeed, ſays Dr. *Halley,* upon turning over very many Hiſtories of Comets, I find nothing at all that can be of any Service in this Affair before the Year 1337, at which Time *Nicephorus Gregoras,* (a *Conſtantinopolitan* Hiſtorian and Aſtronomer) did pretty accurately deſcribe the Path of a Comet among the fix'd Stars, but was too lax as to the Account of the Time; ſo that this moſt doubtful and uncertain Comet only deſerves to begin our Catalogue of Comets for the Sake of its appearing, above 400 Years ago.

It will be in vain to inſiſt longer on the Opinions and Notions of the Antients concerning Comets, as they knew little or nothing of their Nature and Uſe; nor indeed on theſe of the Moderns till we come down to the very laſt Age, wherein were ſufficient Opportunities of obſerving their *Phænomena,* and learned Men enough to reaſon upon them, of whom the principal was Sir *Iſaac Newton,* from whoſe Diſcoveries and Philoſophy, joined with thoſe of Dr. *Halley,* we can gather the following Particulars, which contain all that is known in regard to the *Nature, Philoſophy* and *Aſtronomy* of *Comets.*

I. That Comets belong to that Kind of Bodies which we properly call Planets, and are moved by the ſame Cauſe; *viz.* a *projectile Force* in their Orbit, and a *central Force* toward the Sun, by which Means their Motions become regular and uniform, deſcribing about the Sun Areas always proportioned to the Time, as the other Planets do.

II. That therefore their *Courſe* or *Path* in the Heavens is a *Curve*, and not a *right Line*, as was always ſuppoſed before Sir *Iſaac*'s Time, by the moſt eminent Philoſophers, as *Tycho Brahe*, *Kepler*, *Hevelius*, *Carteſius*, &c. The Curve which they move in is really an *Ellipſis*, in one of whoſe *Foci* is the Sun. Their Orbits differing in nothing from thoſe of the Planets but a greater Degree of Excentricity.

III. As the Orbit of a Comet is leſs or more excentric, the Diſtance to which they recede from the Sun, will be in Proportion leſſer or greater. And it is found by Obſervation that there is in this reſpect a very conſiderable Difference, even ſo great that the Sides of the elliptic Orbit in ſome of them degenerate almoſt into right Lines, particularly that of the Comet 1680.

IV. Thoſe Comets which go to the greateſt Diſtance from the Sun, approach the neareſt to him at their Return; therefore this neareſt Diſtance is very variable; in ſome of them it exceeds the Diſtance of the Earth from the Sun, and others approach extremely near that central Body of Fire; in this reſpect, that of the Year 1680, exceeds by much all others, and that of 1729, has its Perihelion Diſtance more than four times farther from the Sun than the Earth is.

V. The *Periodical Times* of the Comets will, on account of the different Lengths of their Orbits, likewiſe be very different among themſelves, for the ſame Laws govern here as among the Planets, *viz.* that the Squares of the Times which they take to revolve about the Sun, is always proportioned to the Cubes of their greateſt Diſtance from it. The ſhorteſt Time yet known of a cometary Period is of that very Comet which we next expect, which is but 75 Years and a Half at the Mean. The longeſt Period is that of 1680, which is not accompliſhed in leſs than 575 Years. And indeed, theſe two, and one more, are all that are yet determined from Obſervation.

VI. The *Direction* of a Comet's Motion is indeterminate; for they ſteer their Courſes to and from the Sun in any Direction whatever, without regard to the Order of the Signs of the Ecliptic or Points of the Compaſs. In this they differ widely from other Planets which always move from Weſt to Eaſt. But as to the Comets, ſome of them move that Way, and others quite the contrary; and accordingly, we ſay, a Comet is direct or retrograde in Motion.

VII. Another Diſcovery relating to Comets, is, that the Planes of their Orbits have *all Degrees of Elevation* above the Planes of the Ecliptic; whereas thoſe of the Planets are almoſt coincident with it. It is obſerved, that ſome of the Comets Orbits have not *three* Degrees of Elevation, and others have nearly 90.

VIII. The Comets in the *Perihelion* or neareſt Diſtance from the Sun, receive very great *Degrees of Heat*; and in their *Aphelia*, or greateſt Diſtances, they ſuſtain prodigious Degrees of *Cold*: In which Caſe they differ very much from other Planets, whoſe Degree of abſolute Heat is nearly at all Times the ſame.

IX. The Comets, when neareſt the Sun, have extreme Degrees of *Light*, and in the remote Part of their Orbits have ſuch *total Darkneſs*, of which we can have no Ideas. Which, as well as the different Degrees of Heat and Cold, muſt greatly affect the Inhabitants of thoſe Bodies, if any ſuch there are.

X. The *Velocity of a Comet's Motion* is variable in every Part of its Orbit; in ſome of which, when neareſt the Sun, it is incredibly ſwift, and when at the greateſt Diſtance, inconceivably ſlow: Whereas the Motion of other Planets is nearly equable, or at all Times the ſame.

XI. The *Form of a Comet* is different from that of any other Planet; for it conſiſts of a large internal Body which ſhines with reflected Light of the Sun, and often appears of a roundiſh Figure, but not always as the reſt of the Planets do. But another Thing in which they differ from the Planets ſtill more is,

XII. They are all of them encompaſſed with a very large *Atmoſphere*, conſiſting of a certain Kind of fine Matter replete with Clouds and Vapours. This is uſually called the *Head* of the Comet, and the denſer ſhining Body within is called the *Nucleus*; from which,

XIII. There generally ariſes a large *Exhalation* in the Form of a *fiery Beam*, or Train of Light, which is uſually called the *Tail* of the Comet.

XIV. The *Magnitude* of a Comet is very conſiderable, but undoubtedly variable: Some of them are found by Computation to be equal to the Earth itſelf, and that of the Atmoſphere to be ten or twelve Times as much in Diameter, and conſequently the Head or Atmoſphere of ſuch a Comet muſt be a thouſand Times larger than the Earth.

XV. But the *Magnitude of the Tail* of a Comet is ſtill moſt of all ſurpriſing; being found by actual Meaſurement to be oftentimes thirty or forty Millions of Miles, and ſome of them ſeventy and eighty Millions in Length.

XVI. The *Poſition of the Tail* is another remarkable Particular, being always turned towards the Parts which are oppoſite the Sun, but not in a right Line; the extreme Part of the Tail being left a little behind towards the Parts left by the Comet, and therefore the Form of the Tail muſt be ſomething incurvated.

XVII. The *Denſity of a Comet's Tail* is very conſiderable towards the Head of the Comet, but gradually leſſens towards the Extremity: In the higher Parts of the Tail the lucid Vapour is ſo thin as that oftentimes the fix'd Stars are very eaſily ſeen thro' it.

XVIII. The *Number of the Comets* is certainly very great; near forty have already been obſerved with ſo much Accuracy as to leave little room to doubt that they are all different from each other. And a much greater Number ſtill are recorded in Hiſtory. A certain voluminous Author has reckoned no leſs than 415 in Number, to the Year 1665 incluſive: But tho' the Number be certainly very great, it may require many Ages to determine what the Number really is, and on this Account they make not only the moſt ſurpriſing but by far the moſt conſiderable Part of the Solar Syſtem.

XIX. The apparent Path or Tract which the Comet appears to deſcribe among the fix'd Stars in the Heavens, is nearly that of a *great Circle* of the Sphere; on which Account, if proper Obſervations are made during the Time of its Appearance, it will be then an eaſy Matter to repreſent the Courſe it takes upon the Surface of the celeſtial Globe, as we ſhall hereafter ſhew how to perform.

XX. The *apparent Velocity* of a Comet will be greater or leſs than what it really is, according as the Motion of the Earth conſpires with or is contrary to that of the Comet; for when the Earth moves the ſame Way with the Comet, its Motion will be ſlower, but the Comet will appear to move quicker when it moves towards contrary Parts.

XXI. As the Comet aſcends and deſcends above and below the the Plane of the Earth's Motion, the Tail of many of the Comets, when it is in the aſcending or deſcending Node, will ſtrike acroſs the Orbit of the Earth, and ſhould ſuch a Node of the Comet be near the Earth's Orbit, and within it, there would then be a Poſſibility of the Earth's being involved in the denſer Part of that Tail; but the Probability of ſuch an Event's happening would be very little, as the Earth's

Orbit is ſo very large, and the ſame Thing may be obſerved with regard to the reſt of the Planets.

XXII. As the Comets want a *diurnal Parallax*, in general, it is a convincing Proof that they approach not ſo near the Earth as the Moon, whoſe Parallax is very conſiderable.

XXIII. But as their *annual Parallax* is ſufficiently ſenſible, this evidently proves that they deſcend into the Regions of the Planets, and by this Means their Places and Diſtances are eaſily ſubject to Computation, as we ſhall ſhew hereafter.

XXIV. In the laſt Place, the Uſe of a Comet is a Subject of great Enquiry, and in which we can arrive at little more than Conjecture or Probability, but of this we ſhall ſay more by and by.

Theſe are the general Heads concerning Comets: For the Rationale or phyſical Cauſes of theſe Phænomena, we ſhall be obliged to have Recourſe to the Writings of Sir *Iſaac Newton*, who hath hitherto ſtood the ſole Author of this Philoſophy, without any Competitor worth our Notice; eſpecially as with him we find the moſt celebrated modern Philoſophers join in Opinion; as, Dr. *Gregory*, Dr. *Pemberton*, Mr. *Maclaurin*, Mr. *Cotes*: and the learned Commentators on his *Principiæ*. The Subſtance of whoſe Doctrine is as follows.

A Comet is a Sort of Planet revolving in an Orbit, which returns into itſelf with a perpetual Motion. That the Bodies of Comets are fixed and durable like the Bodies of the Planets, for were they nothing elſe but the Vapours or Exhalations of the Earth, of the Sun, or of the Planets, they would by their Paſſage thro' the Neighbourhood of the Sun, have been immediately diſſipated by its Heat. For thus he reaſons with reſpect to the Comet, 1680. When that Comet was in the Perihelion, *December* 8, the Diſtance thereof from the Center of the Sun was to the Diſtance of the Earth from the ſame, as about 6 to 1000. The Sun's Heat on the Comet at that Time was to the Heat of the Summer Sun with us, as 1000000 to 36, or as 28000 to 1: But the Heat of boiling Water is three Times greater than the Heat that dry Earth receives from the Summer Sun; and the Heat of red-hot Iron is about three or four Times greater than that of boiling Water; therefore the Heat which dry Earth, on the Comet, whilſt in its Perihelion might have conceived from the Rays of the Sun, *was about* 2000 *greater than the Heat of red-hot Iron*. But by ſo fierce a Heat, Vapours and Exhalations, and every volatile Matter muſt have been immediately conſumed and diſſipated.

This Comet therefore muſt have received an immenſe Heat from the Sun, and retain that Heat for an exceeding long Time. For a Globe of Iron of an Inch in Diameter, expoſed red-hot to the open Air, will ſcarcely loſe all its Heat in an Hour's Time; but a greater Globe would retain its Heat longer in the Proportion of its Diameter, becauſe the Surface (in Proportion to which it is cooled by the Contact of the ambient Air) is in that Proportion leſs in reſpect of the Quantity of the included hot Matter. And therefore a Globe of red-hot Iron equal to our Earth, that is, about 40000000 Feet in Diameter, would ſcarcely cool in an equal Number of Days, or in above 50000 Years.

To this Account of Sir *Iſaac Newton*, we can only add, that ſuch a prodigious Degree of Heat muſt neceſſarily prove that the fixed and ſolid Parts of a Comet muſt be almoſt infinitely more ſo, than any ſuch like Parts in our Earth; as it is well known that Gold, one of the moſt fixed Bodies with us, will be calcined, vitrified, and its natural Texture intirely altered in the *Focus* of a large Burning-Glaſs, where the Heat is many hundred Times leſs than that which the Comet ſuſtains from the Sun. Alſo that fine fluid Matter that conſtitutes the Atmoſphere of the Comet, can be by no means like the Atmoſphere of our Earth. For were it an *elaſtic Medium,* and whoſe Elaſticity was ſubject to be increaſed by Heat like that of Air, it muſt ſoon have been diſſipated by the increaſing Heat of the Sun; have left the *Nucleus* of the Comet bare, long before it could have attained to its Perihelion. Therefore the fluid and ſolid Parts of a Comet muſt be different from thoſe of a Planet.

Then with reſpect to the Tail of a Comet, Sir *Iſaac* infers, that it is nothing elſe but a very fine Vapour, which the Head or *Nucleus* of the Comet emits by its Heat, and that the Magnitude of the Tail depends principally upon the Degree of Heat it receives from the Sun. This is evident from Obſervation; for, till the Comet comes within a certain Diſtance of the Sun, it is not ſeen with any Train at all; as it approaches nearer, and the Heat increaſes, the Tail begins to ariſe and grow longer and longer about the Perihelion, and a little Diſtance after, it is largeſt of all. Then as the Heat of the Sun decreaſes, the Length of the Tail decreaſes alſo, till at laſt no more appears. Therefore the Tail of a Comet is cauſed by Heat, and is always proportioned to it. Thus alſo the Comets which are neareſt the Sun have generally ſpeaking the longeſt Tails, and thoſe which are more remote the ſhorteſt.

If it ſhould ſeem a Difficulty to any one how thoſe prodigious Tails could be ſupplied from the Atmoſphere of a Comet, our Author has removed that Difficulty by a Computation which he had made on the expanſive Power or Force of an elaſtic Fluid; ſuch as our Air, which is more denſe near the Surface of the Earth, where it is preſſed upon by the whole Weight of the Air above, than it is at a Diſtance from the Earth, where it has a leſs Weight to compreſs it; the Denſity of the Air being always proportioned to the Force which compreſſes it, and conſequently the Air will expand itſelf and become more rare in proportion as it becomes leſs compreſſed. From hence Sir *Iſaac* computes to what Degree of Rarity the Air muſt be expanded according to this Rule, at an Height equal to that of the Semidiameter of the Earth, (which is but about 4000 Miles) and he finds that a Globe of ſuch Air as we breathe here, which is only *one Inch in Diameter*, if it were expanded to a Degree of Rarity which the Air muſt have at the Height now mentioned, would fill all the planetary Regions, even to the very Sphere of *Saturn*, and far beyond. Now, ſince the Air at a greater Height, is ſtill immenſely more rarified; and the Surface of the Atmoſpheres of Comets Tails is uſually about ten Times the Diſtance from the Center of the Comet, as the Surface of the Comet itſelf, and the Tails riſe yet to vaſtly greater Heights; therefore they muſt be exceedingly rare, and tho' on account of the much denſer Atmoſpheres of Comets, and the greater Gravitation of their Bodies towards the Sun, as well as of the Particles of their Air and Vapours mutually one towards another, it may happen that the Air in the celeſtial Spaces, and in the Tails of the Comets is not ſo vaſtly rarefied, yet from ſuch a Computation it is plain that a very ſmall Quantity of Air and Vapour is abundantly ſufficient to produce all the Appearances of the Tails of Comets, and that the Tails of Comets are very rare indeed is evidently proved by the ſhining of Stars thro' them, without the leaſt Diminution of their Splendor.

The Light reflected from a Comet's Tail is but very little in Compariſon of what we uſually imagine it to be. Sir *Iſaac* ſays, it is not greater than that of our Air, determined by the Sun-beams let into a darkened Room thro' a Hole in the Window-ſhutter, an Inch or two in Diameter. This alſo fully appears from viewing the Tail of a Comet with a Teleſcope, which always (to the great Diſappointment of the curious Spectator) appears very faint and languid even in the denſer Parts of it, and the extreme Parts of the Tail make no Appearance at all thro' a Teleſcope.

Having thus ſufficiently accounted for the Magnitude and Light of a Comet's Tail, the next Thing to be conſidered is the Cauſe of the Aſcent of the Tail of a Comet, and alſo the Poſition and Form of it.

As to the Cauſe of the Aſcent of the Tail, *Kepler* aſcribes it to the Rarefaction of the Comet's Atmoſphere by the Heat of the Sun, and the impulſive Force of the Sun-beams carrying along with them the Matter of the Comet's Tail, which alſo accounts at the ſame time for the Direction or Poſition of the Comet's Tail, which is always towards thoſe Parts oppoſite to the Sun. That all the Phenomena of a Comet's Tail depend upon the Heat of the Sun, is what we have before obſerved; and ſince the *Nucleus* or Body of a Comet is heated to that prodigious Degree as has been mentioned, it is but reaſonable to ſuppoſe that the Action of the Sun's Light upon thoſe ignited Particles of the Comet, and its heated Atmoſphere, ſhould carry them away in their own Directions, and ſo cauſe that Appearance of a Train of Light, or the blazing Tail of a Comet. We find, when we attentively conſider the Nature of Things, that the Particles of Light agitate and put all the Parts of Bodies in Motion, particularly the Parts of fluid Bodies, and thoſe Parts of Bodies, whether ſolid or fluid, that are ignited, or real fire, evidently loſe their ignited Particles, and by Degrees become extinct only by the Action of the Sun's Rays. Thus any Fire expoſed to the Sun-beams appears immediately to be robbed of its ignited Parts; the Flame gradually leſſens; the glowing Coal by Degrees becomes extinct, and the whole Fire ſoon goes out. Thus the Flame of a Spirit Lamp loſes all its Light in the Sun-beams. The denſer Flame of a Candle burns languid in the Sun; and many other Phænomena of like Nature we obſerve.

Nay, ſome Philoſophers who have had the Opportunity of very large Burning-glaſſes, four or five Feet in Diameter, have declared, that they have rendered this impulſive Force of the Rays of Light upon Bodies ſenſible to the Eye, for by ſeveral Experiments which they have try'd on light Bodies ſuſpended by a fine Thread, and then throwing the denſe Rays of Light near the Focus of the Glaſs, upon them, it has manifeſtly put them in Motion, and they have been obſerv'd to vibrate backward and forward like a Pendulum: there is therefore no Diſpute to be made, that the Parts of Bodies may be propell'd and carried forward by the Particles of Light in their own Direction, and tho' ſuch Effects of the Sun's Rays are very ſmall and almoſt inſenſible here with us, where the Parts of Matter are very groſs and confin'd in a Denſe Atmoſphere, yet the Caſe is undoubtedly far otherwiſe in thoſe free Spaces through which the Comets move, where ſcarcely any reſiſting Medium can be ſuppoſed, and where the Matter of a Comet's Tail is very fine and liable to be put in Motion with the leaſt Degree of Force, much more by the prodigious *Impetus* of a Particle of Light moving with a Velocity not to be expreſs'd or conceiv'd; agreeable to this notion of the Cauſe of the aſcent of a Comet's Tail, we find the general Form of the Tail is that of a dilating Vapour growing wider and wider towards the extreme Parts, eſpecially when they attain to their full Degree of Heat and greateſt Magnitude.

The Tail indeed does not lie in a right Line Direction from the Sun, nor can we poſſibly ſuppoſe it ſhould, unleſs it were to move in a real *Vacuum* or empty Space, for tho' the Medium thro' which the Comet moves may be exceeding rare and fine, yet ſome degree of Reſiſtance will ariſe to ſo large a moving Body as the Tail of a Comet, and the more rare the Tail is, the greater reſiſtance it will meet with from the Medium, therefore the Tail muſt be in ſome degree incurvated, or left a little behind the Comet in its Motion, ſomewhat like the Flame of a Candle when it is moved gently forward thro' the Medium of Air; and hence it is that we ſee all the Tails of the Comets deviating from the right Line which paſſes through the Sun and the Comet, but moſtly ſo toward the extreme Part.

It remains now to make ſome Enquiry concerning the Uſe of Comets and their Tails, and here we muſt pay the higheſt deference to the Judgment and Opinion of Sir *Iſaac Newton*, who has in the ſtrongeſt Light imaginable repreſented the extenſive Providence of the great Author of Nature, who beſides the furniſhing this Globe of Earth, and without doubt the reſt of the Planets ſo abundantly with every thing Neceſſary for the Support and Continuance of the numerous Races of Plants and Animals, they are ſtocked with, has over and above provided a numerous Train of Comets far exceeding the Number of Planets, to rectify continually, and reſtore their gradual Decay, which is our Author's Opinion concerning them. For ſince the Comets are ſubject to ſuch unequal Degrees of Heat, being ſometimes burnt with the moſt intenſe Degrees of it, at other Times ſcarce receiving any ſenſible Influence from the Sun; it can hardly be ſuppos'd they are deſign'd for any ſuch conſtant Uſe as the Planets. Now the Tails which they emit, like all other Kinds of Vapour, dilate themſelves as they aſcend, and by Conſequence are gradually diſpers'd and ſcatter'd through all the planetary Regions, and thence cannot but be gathered by the Planets having a Power to cauſe all Bodies to gravitate towards them. Theſe Vapours will be drawn in proceſs of Time into this or the other Planets, which happens to act ſtrongeſt upon them.

And by entering the Atmoſpheres of the Earth and other Planets, they may well be ſuppos'd to contribute to the Renovation of the Face of Things, in particular to ſupply the diminution cauſed in the humid Parts by Vegetation and Putrefaction. For Vegetables are nouriſhed by Moiſture, and by Putrefaction are turned in great Part into dry Earth; and an earthy Subſtance always ſubſides in fermenting Liquors; by which Means the dry Parts of the Planets muſt continually increaſe, and the Fluids diminiſh; nay, in a ſufficient length of Time be exhauſted, if not ſupply'd by ſome other Means. It is farther our great Author's Opinion, that the moſt ſubtile and active Parts of our Air, upon which the Life of Things chiefly depends, is deriv'd to us and ſupplied by the Comets. So far are they from portending any Hurt or Miſchief to us, which the natural Fears of Men are ſo apt to ſuggeſt from the Appearance of any Thing uncommon and aſtoniſhing.

Another Uſe of the Comets ſuggeſted by Sir *Iſaac Newton*, is the following; the Reſiſtance which the Comets meet with from the Atmoſphere of the Sun, and of the Medium of the planetary Regions, muſt occaſion a Retardation of their Motion in ſome ſmall degree which may be alſo further promoted by the Attraction of the larger Planets, the Conſequence of which will be, that the central Force will bring them nearer and nearer the Sun in each Revolution, till at length they fall into him, and ſupply Fuel to that immenſe Body of Fire. Nay Sir *Iſaac* has carried this Suppoſition ſo far as to ſay, that fixed Stars (or Suns of other Syſtems) that had been gradually waſted by Light and Vapours emitted from them for a long Time, may be re-kindled by the Comets of their Syſtems falling upon them, and from this freſh Supply of new Fuel, thoſe *Old Stars* acquiring new Splendor, make thoſe *New Stars* which we often obſerve ſuddenly appear in the Heavens, and ſhine with wonderful Brightneſs at firſt, and afterward vaniſh by little and little, of which he enumerates many Inſtances.

Nay further ſtill our judicious Author thinks it not unreaſonable to imagine that the Exhalations that ariſe from the Sun, the fix'd Stars, and the Tails of the Comets may at laſt meet with and fall into the Atmoſpheres of the Planets by their Gravity, and there be condens'd and turn'd into Water and humid Spirits; and from thence by a ſlow heat paſs gradually into the Form of *Salts*, *Sulphurs* and *Tinctures*, and *Mud* and *Clay*, and *Sands*, and *Stones*, and *Coral*, and other *Terreſtrial Subſtances*.

The near Approach of ſome Comets to the Earth's Orbit at particular Times may afford very good Opportunities of determining the Parallax of the Sun, as their Parallaxes are very much larger than that of the Sun, in their *Perigeums*. Dr. *Halley* ſays, that he found by Calculation the Comet of 1680, on *November* 11 Day, 1 H. 6′ was not above the Semidiameter of the Sun to the Northward of the Earth's Path, and had the Earth been there then, he thinks the Parallax of the Comet would have equalled that of the Moon.

Some other Uſes may be made of the Doctrine of Comets; as that they entirely deſtroy the arbitrary Hypotheſis of *Carteſian Vortices*, by their regular and free Motions in all Directions thro' every part of the Heavens; as alſo of the *ſolid Orbs* in which the Planets were ſuppos'd to move by the vain Imagination of ignorant *Schoolmen*. And laſtly, the Argument againſt the Eternity of the Univerſe, drawn from the gradual decay of the Sun, ſtill ſubſiſts and receives new Force from this Theory of the Comets.

We ſhall not take upon us to ſay how far the Fate of the Planetary Syſtem may be affected by Comets, nor particularly what may happen in proceſs of Time to our Earth, ſince among ſuch a Number of revolving Comets, with ſuch prodigious Tails attending them through the planetary Regions, and moving in all Directions among the planetary Orbs, there muſt be ſomething more than common Chance ſuppoſed to guard the Planets from Shocks againſt the Bodies of Comets and Immerſions into their Tails. It is well known to Aſtronomers how near that dreadful Comet of 1680, approach'd to the Earth's Orbit. Alſo the Comets of 1472, 1618, 1684, and the Comet which we now expect, with many others, paſs ſo near the Orbit of the Earth, that it will not be without Reaſon if our Fears and Apprehenſions are conſiderably raiſed thereat *; nor could we have any Satisfaction or Security againſt ſuch alarming Accidents, were it not for the Conſideration, that all the Motions of the Univerſe were at firſt deſigned and produced by a Being of ſufficient Skill to foreſee the moſt diſtant Conſequences; our Earth has hitherto been out of the way when theſe Comets have paſſed by, but it requires a perfect Knowledge of the Motion of Comets, to be able to judge if they will always viſit us in ſo inoffenſive a Manner. It is not indeed poſſible to ſay how far the Earth may be affected by being involved in the Tail of a Comet, eſpecially in the denſer Part near the Atmoſphere, and it is to be preſumed, that we ſhould all be willingly excuſed from this Piece of Knowledge by Experiment.

---

* However the Reader need not be under any needleſs Terror about the Return of this Comet; for if it appears before the Beginning of next *May*, it can do no harm; as he may be eaſily convinced by the View of the Comet's Orbit which I publiſhed ſome Time ago.

From this account of Comets, a Reaſon may be aſſigned why they are not comprehended within the limits of a *Zodiac*, as the Planets are; but, being confined to no Bounds, are with various Motions diſperſed all over the Heavens, namely, to this Purpoſe, That in their *Aphelions* where their Motions are exceeding ſlow, receding to greater Diſtances one from another, they may ſuffer leſs Diſturbance from their mutual Gravitations. And hence it is, that the Comets which deſcend the loweſt, and therefore move the ſloweſt in their Aphelions, ought alſo to aſcend the higheſt.

In the next Place, the Reaſon why the *Planes* of their Motions are not in the Planes of the Ecliptic, or any of the planetary Orbits, is extremely evident, for had this been the Caſe, it would have been impoſſible for the Earth or any of the Planets to have been out of the way of the Comets Tails. Nay, the poſſibility of an immediate Rencounter or Shock of the Body of a Comet would then have been but too frequent, and conſidering how great the Velocity of a Comet is at ſuch a Time, the Colliſion of two ſuch Bodies muſt neceſſarily be deſtructive of each other; nor perhaps could the Inhabitants of Planets long ſurvive thoſe frequent Immerſions in the Tails of Comets as they would be liable to in ſuch a Situation. Not to mention any thing of the Irregularities and Confuſion that muſt happen in the Motion of Planets and Comets, if their Orbits were all diſpos'd in the ſame Plane.

From this Theory of the Comets likewiſe we may eaſily ſee the Reaſon why they are ſo very numerous; for *two* or *three*, or a *very few* Comets, could not anſwer thoſe very great Purpoſes before mentioned. For ſetting aſide the conſtant ſupply of Planetary Moiſture an Eſtimate of which we cannot properly form, it is well known by Experience, that the Fire of the Sun is renewed and recruited very frequently; for the *Maculæ* or Spots in the Sun are only the Parts burnt out, or a dead *Calx* without Fire; And theſe Spots after many Years Appearance and Increaſe, will oftentimes diſappear on a ſudden and will not be ſeen again for ſome Years, which plainly ſhews that ſomething has happened to the Sun, by which thoſe dark or extinct Parts are re-kindled and burn again afreſh; and why may not this ariſe from Comets falling into the Sun? Tho' I am well aſſured from what I have ſeen, that Nature has provided ſome other Means to anſwer this Purpoſe beſides the Bodies of Comets.

Theſe Things premiſed do nearly exhauſt the whole phyſical Theory of Comets in general. The *Aſtronomical Principles* of a Comet's Motion will be too difficult to find a Place here; we ſhall therefore refer the Reader for thoſe Things to Dr. *Gregory*'s *Elements of Aſtronomy*, or the Commentators on Sir *Iſaac Newton*'s *Principia*.

PART

PART II.

The Principles *of Cometary Calculation, and* Tables *of the Elements of the Theory of a* Comet's *Motion, with their Conſtruction and Uſe.*

WE judge it will be an agreeable Amuſement for our Readers to be inſtructed in the *practical Method* of calculating the *Place* and *Diſtance of a Comet*, both from the Sun and the Earth, together with its *Latitude* and *Longitude* in the Ecliptic for any given Time during the Comet's Appearance: Eſpecially as this will require no more than a common Skill in plain Trigonometry, and nothing of this kind has yet been made public. To this end it will be neceſſary to acquaint the Reader with the following Things by way of Definition. Fig. I.

Let A B P C repreſent the Orbit of the Earth, which is in a ſmall Degree elliptical; therefore there will be two Points in which the Earth will be neareſt and fartheſt from the Sun of all others; the firſt is the Point P, where the Earth will be at the leaſt Diſtance from the Sun, which Diſtance is deſigned by P S, and the Point P is called the *Perihelion.*

Through the Points P and S draw the right Line P S A, then will A S be the greateſt Diſtance to which the Earth can go from the Sun, and the Point A is called the *Aphelion.*

Between the Points of neareſt and greateſt Diſtance P and A, there will be one Point B, where the Diſtance of the Earth from the Sun B S will be a *mean* between the greateſt and the leaſt.

This mean Diſtance of the Earth the Aſtronomers always divide into 10000000000 equal Parts, of which Parts they eſtimate every other Diſtance, of which the leaſt Diſtance PS contains 9830800000, and the greateſt Diſtance A S contains 10169000000; but we uſually leave out the five Cyphers, and expreſs thoſe Diſtances by 98308 and 101690, which have the ſame Ratio to each other as the larger Numbers with Cyphers.

About the Sun S as a Center, with the Diſtance S A, the dotted Circle is deſcribed in the ſame Plane, and divided into 12 equal Parts, to which is affix'd the Characters of the twelve Signs reſpectively, as ♈, ♉, ♊, *&c.* which Circle is called the *Ecliptic*, and which the Sun apparently deſcribes every Year, for it will be eaſy to underſtand that in whatever Part of its Orbit the Earth may be in at any time, we ſhall view the Sun in the oppoſite Part of the Ecliptic.

It is uſual with Aſtronomers to conſider the Earth as commencing its Motion from the remoteſt Point of its Orbit A, and from thence to proceed according to the Order of the Signs till it arrives to its loweſt Point P, or its *Perihelion*, from whence it again aſcends to the Point A.

When from the Point A it has deſcribed any Arch A C, if you draw C S, it will contain an Angle A S C, which is called the *Anomaly of the Earth's Motion*, or oftentimes the *Earth's Anomaly*.

In like manner, let *A* D *P* E repreſent the Orbit of a Comet, a part of which N*P*D will lie above the Plane of the Ecliptic, and the other Part N E *A* D will lye below, and the Line N S D, which repreſents the Interſection of the Plane of the Comet's Orbit with the Plane of the Ecliptic, is called the *Line of the Nodes*; and the Points N and D are called the *Nodes*. If the Poſition of the Comet's Orbit be ſuch, that the Courſe of the Comet from A to D be according to the Order of the Signs, then the Point D is called the *aſcending Node* of the Comet, becauſe in that Point the Comet aſcends above the Plane of the Ecliptic, and the Point N is the *deſcending Node*, as there the Comet deſcends below the ſaid Plane.

The Sun S is always in one *Focus* of the Ellipſis; and here ſuppoſe *P* and *A* are the two Points in which the Comets are neareſt and fartheſt from the Sun, then is *P* the *Perihelion*, and *P* S the *Perihelion Diſtance*. Alſo *A* is the *Aphelion*, and S A is the *Aphelion* (or greateſt) Diſtance of the Comet.

Now to apply theſe Things more particularly to Calculations fitted to the Comet which is now expected to return, let ☊ P ☋ repreſent that Part of the Comet's Orbit which is elevated above the Plane of the Ecliptic, as ſhewn in my large *Copper-Plate Print of this Comet*; alſo let the dotted Line ☊ D ☋ repreſent the Path of the Comet projected upon the Plane of the Ecliptic; let P be the *Perihelion*, and Q the Place of the Comet for any given Time; from Q let fall the Per-

Fig. II.

pendicular Q D on the Plane of the Ecliptic, and draw Q N perpendicularly on the Line of Nodes.

Let A T B repreſent one half of the Ecliptic or Orbit of the Earth; let T be the Place of the Earth in its Orbit at the ſame Time that the Comet is at Q, and draw the Lines S Q, S D, Q N, D N; alſo draw T Q, T D and T S.

Then will S Q be the Diſtance of the Comet from the Sun; S D is called the *Curtate Diſtance* of the Comet in the Plane of the Ecliptic; Q N D is the Angle of Inclination of the Comet's Orbit to the Plane of the Ecliptic's; Q S D is the *Heliocentric Latitude* of the Comet, or that which is ſeen from the Sun. The Angle D S N is the *Heliocentric Longitude* from the Node ☋; the Angle Q T D is the *Geocentric Latitude* of the Comet, or that which is ſeen from the Earth; the Angle S T D is the *Geocentric Longitude* of the Comet from the Sun; the Angle T S D is called the Angle of *Commutation.*

Theſe are the principal Lines and Angles, which it is neceſſary the Reader ſhould be acquainted with, in Order to underſtand and practiſe the following Calculations. And as we ſhall make Choice for this Purpoſe of the Comet of 1682, and which is now expected, it will be neceſſary in the firſt Place, to ſhew the Reaſons why we expect its Return, that it may appear we have ſufficient Grounds and Reaſons for our Theory and *Calculations.* To this End we muſt conſider what are the *Criterions* or Proofs of the ſame Comet returning, ſo that we may not be liable to miſtake one for another, and they are as follow.

Firſt, The Intervals or *Periods* of Time in which the Comet appears, muſt be among themſelves nearly equal, and determin'd from Obſervations: But this Criterion alone will not be ſufficient, becauſe different Comets may poſſibly appear at equal Intervals of Time. Therefore

Secondly, The *Aſcending Node* of the ſame Comet muſt be obſerved at each Appearance to have nearly the ſame Place in the Ecliptic. In the

Third Place, it will be neceſſary to find by Obſervation, that the *Inclination of the Plane* of ſuch a Comet's Orbit ſhould be at each Appearance nearly of the ſame Quantity.

Fourthly, the Place of the *Perihelion* muſt alſo be found to poſſeſs the ſame Part of the Ecliptic nearly.

Fifthly, the *Perihelion Diſtance* muſt alſo be very nearly the ſame at each Return.

Sixthly, The *Time* of the Year in which the *Perihelion* happens, muſt be nearly the ſame in all.

Seventhly and *Laſtly*, the ſame Comet returning muſt have always the ſame Direction of Motion; if it be *direct* at one Time, it muſt be *direct* at another. If its Motion be *retrograde* when it firſt appears, it muſt be ſo every Time after.

Now it will eaſily be granted, that if all theſe Criterions are ſo found in the Returns of any Comet, for ſeveral Periods ſucceſſively, they will neceſſarily prove the Comet to be one and the ſame; and farther it muſt be obſerved, that if two or three of thoſe Characteriſtics are well obſerved and aſcertained, it may ſtrongly be preſumed, that it is the ſame Comet that returns, ſince as it is eaſy to be obſerved from the following Table of Comets, no Two among them all agreed preciſely in any one of the foregoing Characters, much leſs can it be ſuppos'd they ſhould agree in any Two or more of them. And we may venture to pronounce it an Impoſſibility, that two different Comets ſhould have all thoſe Seven different Marks of *Identity*.

If therefore, for the Comet of the Year 1682, we can ſhew that moſt of the foregoing Particulars agree to the Comet appeared in 1607, and alſo to the Comet that appeared in 1681, and before that to other Appearances in 1456, 1380, and 1305, we may then moſt certainly conclude, that Comet which made its Appearance in all theſe ſeveral Periods, was one and the ſame. Now for the three laſt Periods, thoſe Things are found from the Obſervations of Mr. *Flamſted* and Dr. *Halley*'s Computation, from the Obſervations of *Kepler* and *Longomontanus*, in 1607; and thoſe of *Apian* in 1531, and are as in the following Table.

	Flamſted				*Kepler.*				*Apian.*			
		°	″	″		°	′	″		°	′	″
The Aſcending Node	♉	21	16	30	♉	17	40	40	♉	15	30	0
The Inclination of the Orbit		17	56	0		17	20	0		17	0	0
The Place of the Perihelion	♒	2	52	45	♒	1	3	40	♒	1	12	0
The Perihelion Diſtance		58328				——	——			57993		
The Time of the Perihelion	*Sep.*	4d	7h	39′	*Oct.*	16d	21h	44′	*Aug.*	25d	19h	0′

From ſuch an Agreement we may fairly conclude, that the Comet in each of theſe Years, *was* the ſame, the Difference which we obſerve in the Periods, is not ſo great but, that, it may be accounted for by the different Powers of Gravity, which the Comet might be affected with from the large Planets *Jupiter* and *Saturn*, in paſſing thro' the Syſtem. The Conſequence of which will be an accelerated or retarded Motion of the Comet, and therefore it will be impoſſible for the Periods to be exactly equal; and this happens to the ſuperior Planets themſelves, for *Saturn* is often found to vary in the Time of his Revolution, ſometimes by the quantity of twelve or thirteen Days; no wonder then if the Difference of a whole twelve Month be found in the Period of a Comet, where a ſmall difference in the attracting Forces will make a very great difference in the Times of their Revolution. 'Tis true, there is a difference alſo in the Place of the Node in the Comet of 1682, and 1607; but in Anſwer to this, it muſt be obſerved, that the preceſſion of the Equinoxes was ſomething more than one Degree in that Interval of Time, when in reſpect to the fixed Stars, the *Aphelion* of the Comet had moved backward near one half a Degree, and the Nodes in the mean Time moved forward near two Degrees; and as this Comet was Retrograde, its *Aphelion* muſt go backward, and its Node forward, for the ſame natural Reaſons as thoſe of the Planet move a contrary way on account of their Motion being according to the Order of the Signs; as to the ſmall Degree of difference there is obſerved in the Inclination of the Planes, it is well known to thoſe who are verſed in the phyſical Part of Aſtronomy, that a gravitating Force towards the Planet *Jupiter*, not being in the ſame Plane with the Comet, will neceſſarily cauſe a ſmall Degree of Deflection towards the Planet, which muſt neceſſarily occaſion a ſmall Alteration in the Inclination of the Plane of its Orbit. Theſe Things being premiſed, it amounts to a Demonſtration that the Comet in the Year 1680, 1607, and 1531, was certainly the ſame, and ſince thoſe of 1456, 1380, and 1305, appear'd at the ſame Interval of Time, and was obſerved nearly at the ſame Times of the Year, there can remain no Doubt of its being the ſame Comet in them all. The Interval or Period conſiſting alternately of *ſeventy five* and *ſeventy ſix Years*; and ſince the Period which is now nearly compleated ſince 1682, is that of ſeventy ſix Years, it will probably throw the Comet into the Year 1758, and its Return then will confirm the Predictions of Sir *Iſaac Newton* and Dr. *Halley*, and be the firſt Inſtance yet known of a Comet's returning according to a previous Calculation. And therefore will greatly contribute to ſignalize the preſent Age, and render the Names of thoſe two *Engliſhmen* famous to the lateſt Poſterity.

That the Reader may have ſome Idea how exactly the Theory of Comets agrees with Obſervations, I ſhall here give a Specimen of both in the Comet under Conſideration, *viz.* of the Longitudes and Latitudes deduced from Obſervations, and the ſame reſulting from Computation, founded on a Theory of their Motions in a *Parabola*; for though the Motion be really in an *Ellipſis*, yet as ſuch an *Ellipſis* is extremely excentric, the Part which the Comet deſcribes about the Sun will not ſenſibly differ from a Parabola; and indeed the Parabola itſelf is only Part of an *Ellipſis*, one of whoſe Focuſes is at an infinite Diſtance, and as the Computations in the Curve of a Parabola are much eaſier than thoſe in an *Ellipſis*, and at the ſame Time ſufficiently exact, they are generally preferred by Aſtronomers.

1682 Appar. Time.	Longitude obſerved.	Longitude computed.	Differ. of Longit.	Lat. N obſerved.	Lat. N. computed	Differ of Latitude
D. H.	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″
Aug. 19 16 38	♌ 18 15 5	♌ 18 14 19	— 0 46	25 49 19	25 48 33	— 0 46
20 15 38	24 47 55	24 48 5	+ 0 10	26 11 50	26 11 40	— 0 10
21 8 21	29 37 51	29 39 3	+ 1 12	26 15 15	26 18 3	+ 2 48
21 16 19	♍ 1 58 0	♍ 1 58 23	+ 0 23			
22 8 8	6 30 8	6 32 10	+ 2 2	26 4 35	26 6 37	+ 2 2
29 8 20	♎ 12 35 55	♎ 12 38 19	+ 2 24	18 37 27	18 35 3	— 2 24
30 7 45	15 34 42	15 35 58	+ 1 16	17 24 56	17 24 11	— 0 45
Aug. 31 8 21	18 16 20	18 17 30	+ 1 10			
Sep. 1 7 33	20 28 12	20 29 31	+ 1 19	15 11 37	15 11 23	— 0 14
4 7 22	25 29 36	25 39 34	— 0 2	12 22 29	12 22 42	+ 0 13
5 7 32	26 58 20	26 57 45	— 0 35	11 31 26	11 33 34	+ 2 8
8 7 16	♎ 29 56 0	♎ 29 54 40	— 1 20	9 25 31	9 26 26	+ 0 55
9 7 26	♏ 0 41 36	♏ 0 39 39	— 1 57	8 49 2	8 49 0	— 0 2

Now when it is conſidered how ſmall theſe Differences are, and that ſome of them may ariſe from Obſervation, and in ſome Part owing to the irregular Refractions of the Air, not to mention that the beſt of our Inſtruments will ſeldom perform to the Preciſeneſs of half a Minute or ten Seconds. I ſay when all this is conſidered, it will evidently appear, to what great Exactneſs and Perfection the Theory of Comets is already arrived, though as yet but in its Infancy. And certain it is that theſe Differences between the obſerved and computed Places of the Comet, are not greater than the Errors we uſually find in the Theories of the Primary Planets, which for Ages paſt have been cultivated by Aſtronomers.

Therefore the Method of Computation, or Cometary Caculus, ought now to be propoſed as a Thing not only in itſelf delightful and entertaining, but at this Time very nececeſſary, when as many People as poſſible ſhould have it in their Power to confirm and eſtabliſh the Theory, by making and comparing together their Obſervations of the Comet when it ſhall appear; and having made all other neceſſary Preparations for that Purpoſe, they may find the Elements and proper Numbers to go to work with in the following Tables, to which we ſhall ſubjoin their Uſes, and illuſtrate the ſame by proper Precepts and Examples, in a Solution of all the common Problems or Caſes that can occur in this Affair.

The firſt Table will be that of the Aſtronomical Elements of the Theory of the principal Comets that have been hitherto obſerved; the firſt Part of which Table, *viz.* to the Year 1698, was compoſed by Dr. *Halley*, and the remaining Part to the Year 1748 we find in *M. de la Caille*, ſo that the whole Table contains no leſs than 39 Comets, ſuppoſing they were all different one from the other. But it appears from theſe Elements, that three of the Comets therein mentioned, *viz.* thoſe of 1682, 1607, and 1531, are undoubtedly the ſame as we have before obſerved.

Table

TABLE I. The *Aſtronomical* Elements of the Theory of all the Principal Comets to the Year 1698, by Dr. Halley.

Year of Apparition	Place of the aſcending Node.				Inclination of the Orbit.			Place of the Perihelion.				Diſtance of Perihelion.	Logarith. of the Perihelion Diſtance.	Mean Times of paſſing the Perihelion. O. S.				Direction of Motion.
	S.	D.	M.	S.	D.	M.	S.	S.	D.	M.	S.				D.	H.	M,	
1337	♊	24	21	0	32	11	0	♉	7	59	0	40666	9,609236	June	2	6	35	Retrogr.
1472	♑	11	46	20	5	20	0	♉	15	33	30	5427	9.734584	Feb.	28	22	44	Retrogr.
1531	♉	19	25	0	17	56	0	♒	1	39	0	56700	9,753583	Aug.	24	21	27	Retrogr.
1532	♊	20	27	0	32	36	0	♋	21	7	0	50910	9,706803	Oct.	19	22	5	Direct.
1556	♍	25	42	0	32	6	30	♑	8	50	0	46390	9,666424	Apr.	21	20	10	Direct,
1577	♈	25	52	0	74	32	45	♌	9	22	0	18342	9,263447	Oct.	26	18	39	Retrogr.
1580	♈	18	57	20	64	40	0	♋	19	5	50	59628	9,775450	Nov.	28	15	3	Direct.
1585	♉	7	42	30	6	4	0	♈	8	51	0	109358	10,038850	Oct.	7	19	18	Direct.
1590	♍	15	30	40	29	40	40	♏	6	54	30	57661	9,760882	Feb.	8	4	10	Retrogr.
1593	♍	14	14	15	87	58	0	♍	26	19	0	89113	8,949940	July	18	13	48	Direct.
1596	♒	12	12	30	55	12	0	♏	18	16	0	51293	9,710058	Aug.	10	20	10	Retrogr.
1607	♉	20	21	0	17	2	0	♒	2	16	0	58680	9,768490	Oct.	26	3	44	Retrogr.
1618	♊	16	1	0	37	34	0	♈	2	14	0	37975	9,579498	Nov.	8	12	17	Direct.
1652	♊	28	10	0	79	28	0	♈	28	18	40	84750	9,928140	Nov,	12	15	34	Direct.
1661	♊	22	30	30	32	35	50	♋	25	58	40	44851	9.651772	Jan.	27	0	4	Direct.
1664	♊	21	14	0	21	18	30	♍	10	41	25	102575½	10,011044	Dec.	4	11	53	Retrogr.
1665	♏	18	2	0	76	5	0	♊	11	54	30	10649	9,027309	April	24	5	23	Retrogr.
1672	♑	27	30	30	83	22	10	♉	16	59	30	69739	9,843476	Mar.	1	9	0	Direct.
1677	♏	26	49	10	79	3	15	♌	17	37	5	28059	9,448072	May	6	0	43	Retrogr.
1680	♑	2	2	0	60	56	0	♐	22	39	37	612½	7,787106	Dec.	18	0	13	Direct.
1682	♉	21	16	30	17	56	0	♒	2	52	45	58328	9.765877	Sep.	14	7	44	Retrogr.
1683	♍	23	23	0	83	11	0	♊	25	29	30	56020	9.748343	July	13	3	5	Retrogr.
1684	♐	28	15	0	65	48	40	♏	28	52	0	96015	9,982339	June	8	10	24	Direct.
1686	♓	20	34	40	31	21	40	♊	17	0	30	32500	9,511883	Sep-	16	14	37	Direct.
1698	♐	27	44	15	11	46	0	♑	0	51	15	69129	9,839660	Oct.	18	16	52	Retrogr.

The above Table continued to the Year 1748, by M. De la Caille. O. S.

1699	♌	21	45	35	69	20	0	♏	2	31	6	74400	9,871570	Jan.	13	8	32	Retrngr.
1702	♎	9	25	15	4	30	0	♌	18	41	3	64590	9,810165	Mar.	13	14	22	Ditect.
1706	♈	13	11	40	55	14	10	♊	12	29	10	42581	9,629218	Jan.	30	4	32	Direct,
1707	♉	22	46	35	88	36	0	♊	19	54	56	85974	9,934368	Dec.	11	23	39	Direct.
1718	♌	8	43	0	30	20	0	♌	1	30	0	102655	10,011380	Jan.	14	23	48	Retrogr.
1723	♈	14	16	0	49	59	0	♉	12	52	20	99865	9,999414	Sep.	27	16	20	Retrogr.
1729	♒	10	32	37	76	58	4	♒	22	40	0	4 26141	10,629552	June	25	11	6	Direct.
1737	♏	16	22	0	18	20	45	♒	25	55	0	22283	9,347960	Jan.	30	8	30	Direct.
1739	♈	27	25	14	55	42	44	♋	12	38	40	67358	9,828388	June	17	10	9	Retrogr.
1742	♎	5	38	29	66	59	14	♏	7	35	13	76568	9,884049	Feb.	8	4	48	Retrogr.
1743	♊	18	21	15	2	19	33	♋	2	41	45	83501	9,921690	Jan.	10	20	35	Direct.
1744	♉	15	46	11	47	5	18	♎	17	10	0	22249½	9.347325	Mar.	1	8	13	Direct.
1747	♒	27	18	50	79	6	20	♑	7	2	0	219851	10,342128	Mar.	3	7	20	Retrogr.
1748	♏	22	52	15	85	27	0	♏	5	0	50	84067	9,924624	Apr.	28	19	35	Retrogr.

The Uſe of this Table the Reader will eaſily perceive is only to aſſign the Place of the aſcending Node, the Inclination of the Orbit, the Place of the Perihelion in the Ecliptic, the Diſtance of the Comet in the Perihelion, the Logarithm of that Diſtance, the equated Time of the Comet's being in the Perihelion, and the Direction of the Comet's Motion; all which are previouſly neceſſary to be known for every Comet, in order to conſtruct the Orbit and calculate its Place therein.

The next Table neceſſary, is for finding the true Anomaly of a Comet, or the Place in its Orbit for any given Time, before or after the Time of the Perihelion, in the foregoing Tables. This Table conſiſts only of two Columns, one containing the Number of Days from the Perihelion in the *Parabolic Orbit* of a Comet, whoſe Perihelion Diſtance is exactly equal to the mean Diſtance of the Earth from the Sun. The other Column contains the true Anomalies in ſuch an Orbit, correſponding to thoſe Days reſpectively; by means therefore of theſe Numbers we can find the true Anomaly, or Place of any other Comet in its Orbit for any given Number of Days from the Perihelion, as will appear by the Precept of Problem III.

Table II. for calculating the Motions and Places of Comets in a Parabolic Orbit.

The perihelion dist. tn days.	True Anamoly			The perihelion dist. in days.	True Anomaly			The perihelion dist. in days.	True Anamoly			The perihelion dist. in days.	True Anomaly			The perihelion dist. in days.	True Anomaly		
	D.	M.	S.		D.	M.	S.		D.	M.	S		D.	M.	S		D.	M.	S.
1	1	23	37	41	49	53	32	81	77	56	10	121	93	42	37	161	103	39	34
2	2	47	12	42	50	49	38	82	78	26	30	122	94	0	48	162	103	51	42
3	4	10	40	43	51	44	52	83	78	56	25	123	94	18	47	163	104	3	44
4	5	34	0	44	52	39	15	84	79	25	55	124	94	36	34	164	104	15	40
5	6	57	8	45	53	32	48	85	79	54	59	125	94	54	9	165	104	27	29
6	8	20	2	46	54	25	31	86	80	23	37	126	95	11	32	166	104	39	13
7	9	42	38	47	55	17	26	87	80	51	55	127	95	28	44	167	104	50	50
8	11	4	54	49	56	8	31	88	81	19	48	128	95	45	45	168	105	1	20
9	12	26	46	46	56	58	48	89	81	47	18	129	96	2	35	169	105	13	45
10	13	48	14	50	57	48	18	90	82	14	25	130	96	19	14	170	105	25	4
11	15	9	14	51	58	37	2	91	82	41	10	131	96	35	42	171	105	36	17
12	16	29	43	52	59	25	1	92	83	7	33	132	96	52	0	172	105	47	25
13	17	49	39	53	60	12	15	93	83	33	36	133	97	8	7	173	105	58	27
14	19	9	1	54	60	58	44	94	83	59	17	134	97	24	4	174	106	9	23
15	20	27	47	55	61	44	30	95	84	24	38	135	97	39	51	175	106	20	14
16	21	45	53	56	62	29	32	96	84	49	39	136	97	55	28	176	106	30	59
17	23	3	19	57	63	13	52	97	85	14	20	137	98	10	56	177	106	41	39
18	24	20	3	58	63	57	30	98	85	38	42	138	98	26	14	178	106	52	13
19	25	36	3	59	64	40	28	99	86	2	44	139	98	41	23	179	107	2	43
20	26	51	17	60	65	22	45	100	86	26	28	140	98	56	22	180	107	13	7
21	28	5	45	61	66	4	23	101	86	49	55	141	99	11	13	181	107	23	26
22	29	19	25	62	66	45	22	102	87	13	2	142	99	25	54	182	107	33	40
23	30	32	16	63	67	26	42	103	87	35	53	143	99	40	27	183	107	43	50
24	31	44	17	64	68	5	27	104	87	58	26	144	99	54	50	184	107	53	54
25	32	55	27	65	68	44	34	105	88	20	43	145	100	9	6	185	108	3	54
26	34	5	45	66	69	23	5	106	88	42	43	146	100	23	13	186	108	13	48
27	35	15	11	67	70	1	1	107	89	4	26	147	100	37	12	187	108	23	38
28	36	23	45	68	70	38	22	108	89	25	53	148	100	51	2	188	108	33	23
29	37	31	25	69	71	15	9	109	89	47	5	149	101	4	45	189	108	43	5
30	38	38	11	70	71	51	23	110	90	8	1	150	101	18	20	190	108	52	41
31	39	44	4	71	72	27	4	111	90	28	42	151	101	31	47	191	109	2	13
32	40	49	3	72	73	2	13	112	90	49	8	152	101	45	6	192	109	11	40
33	41	53	9	73	73	36	51	113	91	9	20	153	101	58	18	193	109	21	3
34	42	56	19	74	74	10	58	114	91	29	17	154	102	11	22	194	109	30	22
35	43	58	35	75	74	44	34	115	91	49	0	155	102	24	19	195	109	39	37
36	44	59	58	76	75	17	40	116	92	8	30	156	102	37	9	196	109	48	47
37	46	0	27	77	75	50	18	117	92	27	45	157	102	49	52	197	109	57	53
38	47	0	2	78	76	22	28	118	92	46	48	158	103	2	27	198	110	6	55
39	47	58	44	79	76	54	9	119	93	5	37	159	103	14	56	199	110	15	53
40	48	56	34	80	77	25	23	120	93	24	13	160	103	27	18	200	110	24	47

E

A third Table is neceſſary for finding the Decimal Parts of a Day, as ſuch a Table is not always at Hand, it will be proper to give it here.

TABLE III.

Hours	Decimal Parts of a Day:
1	0,041666
2	0,083333
3	0,125
4	0,16666
5	0,208333
6	0,25
7	0,291666
8	0,333333
9	0,375
10	0,416666
11	0,453333
12	0,5
13	0,541666
14	1,583333
15	0,625
16	0,666666
17	0,708333
18	0,75
19	0,791666
20	0,833333
21	0,875
22	0,916666
23	0,958333

As in all Aſtronomical Calculations it is neceſſary to find the Place of the Earth and Sun, ſo here the true Place of the Earth in its Orbit, and the apparent Place of the Sun in the Ecliptic, will be neceſſary to be known, before we can find the Latitude and Diſtance of a Comet from the Earth, therefore the following Table of the mean Motion of the Sun, for any given Year, Month, Day, Hour, Minute, and Second, will be requiſite, and its Uſe will be ſufficiently exemplified in the Solution of the firſt Problem.

TABLE IV. The Mean Motion of the Sun, *&c.*

Radical Year.	The Mean Motion of the Sun from the Vernal Equinox.				The Mean Motion of the Earth's Perihelion from the Equinox.				The Preceſſion of Equinoxes.			The Mean Motion of the Sun for Months.				
	S.	°	'	"	S.	°	'	"	°	'	"		S.	°	'	"
1	9	07	53	3	2	14	02	30	5	9	0	January	0	0	59	8
1301	9	19	13	9	3	4	53	30	26	29	20	February	1	01	32	27
1581	9	19	49	26	3	6	0	10	27	16	20	March	1	29	8	20
1601	9	19	50	30	3	6	16	50	27	32	40	April	2	29	41	38
1621	9	20	07	34	3	6	33	30	27	49	20	May	3	29	15	48
1641	9	20	16	38	3	6	50	10	28	6	0	June	4	29	49	6
1661	9	20	25	42	3	7	6	10	28	22	40	July	5	29	23	16
1681	9	20	34	46	3	7	23	30	28	39	20	Auguſt	7	29	56	34
1701	9	20	43	50	3	7	40	10	28	56	0	September	8	00	29	52
1721	9	20	52	54	3	7	56	50	29	12	40	October	9	00	4	2
1741	9	21	01	58	3	8	13	30	29	29	20	November	10	00	37	20
1761	9	21	11	2	3	8	30	10	29	46	0	December	11	00	11	30
1781	9	21	20	6	3	8	46	50	30	2	40					
1801	9	21	29	11	3	9	3	30	30	19	20					

Julian Years.	Mean Motion of the Sun for compleat Years				Days	Mean Motion for Days				P. M	H. M. S				H. M. S.			
	S.	°	'	r		S.	°	'	"	"		° ' "	' " '''	" ''' ''''		° ' "	' " '''	" ''' ''''
					1	0	0	59	8	0	1	0	2	28	31	1	16	23
					2	0	1	58	17	0	2	0	4	56	32	1	18	51
1	11	29	45	40	3	0	2	57	25	0	3	0	7	24	33	1	21	19
2	11	29	31	20	4	0	3	56	33	1	4	0	9	51	34	1	23	47
3	11	29	17	0	5	0	4	55	42	1	5	0	12	19	35	1	26	14
4	0	0	1	48	6	0	5	54	50	1	6	0	14	47	36	1	28	42
5	11	29	47	28	7	0	6	53	58	1	7	0	17	15	37	1	31	10
6	11	29	33	8	8	0	7	53	7	1	8	0	19	43	38	1	33	38
7	11	29	18	48	9	0	8	52	15	1	9	0	22	11	39	1	36	6
8	0	0	3	36	10	0	9	51	23	1	10	0	24	38	40	1	38	34
9	11	29	49	16	11	0	10	50	32	2	11	0	27	6	41	1	41	2
10	11	29	34	57	12	0	11	49	40	2	12	0	29	34	42	1	43	30
11	11	29	20	17	13	0	12	48	48	2	13	0	32	2	43	1	45	57
12	0	0	5	26	14	0	13	47	57	2	14	0	34	30	44	1	48	25
13	11	29	51	6	15	0	14	47	5	2	15	0	36	58	45	1	50	33
14	11	29	36	46	16	0	15	46	13	2	16	0	39	25	46	1	53	21
15	11	29	22	26	17	0	16	45	22	2	17	0	41	53	47	1	55	49
16	0	0	7	14	18	0	17	44	30	2	18	0	44	21	48	1	58	16
17	11	29	52	54	19	0	18	43	38	3	19	0	46	49	49	2	0	44
18	11	29	38	34	20	0	19	42	47	3	20	0	49	17	50	2	3	12
19	11	29	24	14	21	0	20	41	55	3	21	0	51	45	51	2	5	40
20	0	0	9	4	22	0	21	41	3	3	22	0	54	13	52	2	8	8
40	0	0	18	8	23	0	22	40	12	3	23	0	56	40	53	2	10	36
60	0	0	27	12	24	0	23	39	20	3	24	0	59	8	54	2	13	3
80	0	0	36	16	25	0	24	38	28	3	25	1	1	36	55	2	15	31
100	0	0	45	20	26	0	25	37	37	4	26	1	4	4	56	2	17	59
200	0	1	30	41	27	0	26	36	45	4	27	1	6	32	57	2	20	27
300	0	2	16	1	28	0	27	35	53	4	28	1	9	0	58	2	22	55
400	0	3	1	22	29	0	28	35	2	4	29	1	17	27	59	2	25	23
500	0	3	46	42	30	0	29	34	10	4	30	1	13	55	60	2	27	51
1000	0	7	33	25	31	1	00	33	18	4								

N. B. In Leap Year, after *February*, add a Day to the given Time, and with it the Motion for a Day. Alſo in all Computations after the end of Year 1752, you muſt deduct eleven Days from the given Time, by reaſon of the New Style.

After the *Mean Anomaly*, or Motion of the Earth is obtained from Table IV. another Table will be neceſſary to give the true Place of the Earth in its Orbit, containing ſuch Numbers as are uſually called the *Equation of the Earth's Orbit*, and while the Earth is going from the Aphelion to the Perihelion, theſe Numbers which correſpond to the given Sign and Degree of the Earth's mean Anomaly are to be ſubſtracted from the ſaid Anomally; but in the other half Part of the Orbit they are to be added to it, and the *Difference* in one Caſe, and the *Sum* in the other will give the true Place of the Earth in its Orbit, as in the Examples of Problem the firſt.

TABLE

TABLE V. The EQUATION of the EARTH's ORBIT.

Subſtract

Earth's mean Anomaly.	*Sign* 0			1			2			3			4			5			
	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	
0	0	00	00	0	56	56	1	39	28	1	56	20	1	41	34	0	59	2	30
1	0	01	58	0	58	39	1	40	28	1	56	20	1	40	33	0	57	14	29
2	0	03	57	1	0	21	1	41	27	1	56	20	1	39	30	0	55	26	28
3	0	05	56	1	2	3	1	42	24	1	56	17	1	38	26	0	53	37	27
4	0	07	55	1	3	43	1	43	21	1	56	13	1	37	20	0	51	47	26
5	0	09	54	1	5	22	1	44	15	1	56	4	1	36	11	0	49	55	25
6	0	1	53	1	7	0	1	45	8	1	55	54	1	35	1	0	48	3	24
7	0	13	51	1	8	37	1	45	58	1	55	42	1	33	49	0	46	10	23
8	0	15	48	1	10	13	1	46	47	1	55	28	1	32	36	0	44	16	22
9	0	17	46	1	11	48	1	47	33	1	55	12	1	31	20	0	42	21	21
10	0	19	44	1	13	22	1	48	19	1	55	53	1	30	3	0	40	26	20
11	0	21	40	1	14	53	1	49	1	1	54	32	1	28	45	0	38	30	19
12	0	23	36	1	16	24	1	49	42	1	54	10	1	27	25	0	36	32	18
13	0	25	33	1	17	53	1	50	22	1	53	46	1	26	3	0	34	34	17
14	0	27	29	1	19	22	1	50	59	1	53	19	1	24	39	0	32	36	16
15	0	29	24	1	20	49	1	51	34	1	52	50	1	23	14	0	30	36	15
16	0	31	19	1	22	14	1	52	7	1	52	19	1	21	47	0	28	37	14
17	0	33	13	1	23	38	1	52	38	1	51	46	1	20	19	0	26	37	13
18	0	35	7	1	25	0	1	53	8	1	51	11	1	18	48	0	24	36	12
19	0	37	1	1	26	22	1	53	35	1	50	35	1	17	17	0	22	34	11
20	0	38	54	1		42	1	54	0	1	49	59	1	15	44	0	20	32	10
21	0	40	44	1	28	58	1	54	23	1	49	14	1	14	10	0	18	30	9
22	0	42	35	1	30	4	1	54	44	1	48	32	1	12	34	0	16	28	8
23	0	44	26	1	31	29	1	55	3	1	47	47	1	10	57	0	14	26	7
24	0	46	16	1	32	42	1	55	21	1	46	59	1	9	19	0	12	22	6
25	0	48	5	1	33	54	1	55	35	1	46	10	1	7	39	0	10	19	5
26	0	49	52	1	35	3	1	55	48	1	45	20	1	5	58	0	8	16	4
27	0	51	40	1	36	12	1	55	59	1	44	26	1	4	16	0	6	12	3
28	0	53	26	1	37	19	1	56	9	1	43	31	1	2	32	0	4	8	2
29	0	55	11	1	38	24	1	56	15	1	42	34	1	0	48	0	2	4	1
30	0	56	56	1	39	28	1	56	20	1	41	35	0	59	3	0	0	0	0
	Sign 11			10			9			8			7			6			

Add

The true Place of the Earth in its Orbit being thus obtained, it will next be neceſſary to aſſign the *Diſtance* of the Earth from the Sun; and ſince in Calculations it is neceſſary to work by the *Logarithms* of Numbers, therefore this Table exhibits the *Logarithms of the Diſtances* of the Earth correſponding to every Degree of Anomaly; the Uſe of which is ſufficiently illuſtrated in Problem the 2d, and its Conſtruction very evident from the foregoing Definitions of Figure 1.

TABLE VI. Of LOGARITHIMS for the Diſtances of the Earth from the Sun.

Mean Anomalies of the Earth.

0	Sign 0.	Sign 1.	Sign 2.	Sign 3.	Sign 4.	Sign 4.	0
0	5,007287	5,006375	5,003778	5,000128	4 996381	4,993588	30
1	5,007286	5,006313	5,003669	4,999999	4,996267	4,993522	29
2	5,007284	5,006249	5,003559	4,999870	4,996154	4,993459	28
3	5,007280	5,006184	5,003447	4,999740	4,996042	3,993398	27
4	5,007273	5,006117	5,003334	4,999611	4,995931	4,993339	26
5	5,007264	5,006048	5,003220	4,999482	4,995822	4,993282	25
6	5,007253	5,005977	5,003105	4,999352	4,995714	4,993226	24
7	5,007240	5,005004	5,002989	4,999223	4,995607	4,993173	23
8	5,007225	5,005829	5,002872	4,999094	4,995501	4,993122	22
9	5,007208	5,005753	5,002755	4,998965	4,995397	4,953074	21
10	5,007189	5,005675	5,002636	4,998837	4,995294	4,993028	20
11	5,007167	5,005595	5,002516	4,998762	4,995193	4,992984	19
12	5,007144	5,005513	5,004396	4,998581	4,995094	4,992942	18
13	5,007119	5,005430	5,002275	4,998454	4,994996	4,992903	17
14	5,007092	5,005345	5,002153	4,998327	4,994899	4,992866	16
15	5,007062	5,005258	5,002030	4,998200	4,994804	4,992831	15
16	5,007030	5,005170	5,001907	4,998074	4,994711	4,992798	14
17	5,006997	5,005080	5,001787	4,997948	4,994619	4,992768	13
18	5,006961	5,004988	5,001659	4,997823	4,994529	4,992740	12
19	5,006923	5,004885	5,001534	4,997698	4,994441	4,992714	11
2	5,006883	5,004801	5,001408	4,997574	4,994354	4,992691	10
21	5,006842	5,004705	3,001282	4,997451	4,994269	4,992670	9
22	5,006798	5,004607	5,001155	4,997329	4,994186	4,992652	8
23	5,006752	5,004508	5,001028	4,997207	4,994105	4,992636	7
24	5,006704	5,004408	5,000900	4,997086	4,994025	4,992622	6
25	5,006654	5,004306	5,000772	4,996966	4,993947	4,992611	5
26	5,006602	5,004203	5,000644	4,996847	4,993871	4,992602	4
27	5,006548	5,004099	5,000715	4,996729	4,993798	4,992595	3
28	5,006492	5,003983	5,000384	4,996612	4,993726	4,992591	2
29	5,006434	5,003886	5,000257	4,996496	4,993656	4,992589	1
30	5,006375	5,003778	5,000128	4,996381	4,993588	4,992588	0
0	Sign 1.	Sign 10.	Sign 9.	Sign 8.	Sign 8.	Sign 6.	0

Every Thing hitherto ſaid, has been upon a Suppoſition that the Motion of a Comet is in a Parabolic Orbit; but it is well known that Orbit is an *Ellipſis*; and leſt our Calculations ſhould be thought deficient, we ſhall next give Dr. *Halley*'s Table for computing the Place of the preſent Comet in its true *Elliptic Orbit*; and to underſtand the Conſtruction thereof, let P B H be the Ellipſis deſcribed about the Sun S in the Focus; C P the greater Semi-axis, and C H the leſſer Semi-axis, P A a Circle circumſcribed about the Ellipſis, P S the Diſtance of the Perihelion, and C S the Excentricity of the Orbit; Let the Place of the Comet be in B, from which draw the Ordinate B D perpendicular to the Axis, and let this produced meet the Circle in A, and draw A P, A S, B P, B S, and in C A make C E = C S, and draw E G, perpendicular to C P. Then according to *Kepler*'s Law, the Area P S A P will be to the whole Area of the Circle; alſo P S B P to the whole Area of the Ellipſis, as the Time in which the Comet deſcribes the Arch B P, to the whole periodical Time in which the Comet deſcribes the whole Ellipſis.

But the area P S A P is made up of the circular Segment A P A and the Triangle P S A, the double of which Triangle is P S × A D, the Sine of the Angle A C P; but the double of the Segment, is the Exceſs of the Arch A P above the Sine A D × C P or Radius. Now put the Radius C P = s, and P S = b, and any given Area P A S P = a, to find the Line A D = z the Sine of the Anomaly of the Excentric A C P; now $z\,b$ is double the Triangle P S A, and by a well known Theorem, the circular Arch A P $= z + \frac{1}{6} z^3 + \frac{3}{40} z^5 + \frac{5}{112} z^7$, &c. Whence the double Area of the Segment P A P will be $\frac{1}{6} z^3 + \frac{3}{40} z^5 + \frac{5}{112} z^7$, &c. And therefore $2\,a = b\,z + \frac{1}{6} z^3 + \frac{3}{40} z^5 + \frac{5}{112} x^7$, &c. The Root z of this Equation, being extracted gives A D, the Sign of the Anomaly A C P, and the verſed Sine P D; and if it be made C P to C S as P D to S G, then P G (equal to S G + P S) will be equal to B S, the Diſtance of the Comet from the Sun. And laſtly, let it be made as C P to C H ſo is A D to B D, which will be the Sine to the true Anomaly or Angle P S B to the Radius B S.

But becauſe of the great Difficulty and Labor of extracting the Root of z of the above infinite Series, the Doctor has with great Labour compoſed the following Table, which will give the Angle from the Perihelion, or true Anomaly of the Comet, anſwering to the ſeveral Degrees of Anomaly of the Excentric, which is as far as is required for the preſent Comet, *viz.* to 78 Degrees on either Side the Perihelion, as alſo the Diſtance of the Comet from the Sun for each reſpective Degree of Anomaly; this he has done by computing the mean Motion of the Comet for every Degree, and 12 Minutes of the mean Anomaly of the Excentric, which mean Motion is only the double Area of the mixtilineal Space P A S P mentioned above, And ſince the longer Axis of this Ellipſis is to the Diameter of the Earth's Orbit as $75\frac{1}{2}$ to 1, the mean Diurnal Motion of the Comet will be to that of the Earth or Sun, as 1 to $75\frac{1}{2}$, but the mean Motion of the Sun is 59′ 8″ *per* Day, therefore the mean Diurnal Motion of the Comet 0° 0′ 47″ and putting the Radius $= 1$, the Length of the Arch of 0′ 47″ will be 0,000227843, which will be as the mean Diurnal Motion of the Comet at the Extremity H of the leſſer Axis, and has the ſame Ratio to the Circumference of the Circle as one Day has to the periodical Time, and as the Elliptic Area which the Comet deſcribes in one Day, by a Ray drawn to the Sun, has to the Area of the whole Ellipſis.

Therefore this ſmall Arch 0,000227843 may be very commodiouſly uſed for the Meaſure of the mean Motion of the Comet; and therefore its Logarithm 6.357636, added to the Logarithm of the given Time from the Perihelion, gives the Logarithm of the mean Motion of the Comet for the given Time, which mean Motion being compared with the Numbers of the ſecond Column in the Table, you will thence find the *true Anomaly* in the 4th Column for the Time propoſed.

Then in the 6th Column the Doctor has given the Logarithms of the Ratio of the Perihelion Diſtance P S to all other Diſtances S B within the Compaſs of the Table; and conſequently having the Logarithm of the Ratio of the Diſtance, you have the Diſtance itſelf S B for the given Time, as will be ſhewn in its proper Place.

TABLE

TABLE VII.

A Table of the Mean Motion, Anomaly, *and* Diſtance *from the Sun, computed for the* ELLIPTIC ORBIT *of the Comet,* 1682.

Anomaly of the Eccentric.	*Mean Motion of the Comet.*	*Difference.*	*Angle from the Perihelion.*	*Difference.*	*Logarithm of Diſtance from the Sun.*	*Difference.*
° ′			° ′ ″	° ′ ″		
0 0	0,00000000		0 0 0		0,000000	
		11383		1 33 12		78
0 12	0,00011383		1 33 12		0,000078	
		11387		1 33 11		236
24	0,00022770		3 6 23		0,000314	
		11396		1 33 6		392
36	0,00034166		4 39 29		0,000706	
		11408		1 33 1		548
48	0,00045574		6 12 30		0,001254	
		11424		1 32 51		704
1 0	0,00056998		7 45 21		0,001958	
		11445		1 32 42		859
12	0,00068443		9 18 3		0,002817	
		11470		1 32 31		1013
24	0,00079913		10 50 34		0,003830	
		11498		1 32 16		1164
36	0,00091411		12 22 50		0,004994	
		11532		1 32 0		1317
48	0,00102943		13 54 50		0,006311	
		11568		1 31 43		1467
2 6	0,00114511		15 26 33		0,007778	
		11609		1 31 22		1618
12	0,00126120		16 57 55		0,009396	
		11655		1 31 4		1760
24	0,00137775		18 28 59		0,011156	
		11704		1 30 40		1908
36	0,00149479		19 59 39		0,013064	
		11758		1 30 14		2051
48	0,00161237		22 29 53		0,015115	
		11815		1 29 47		2192
3 0	0,00173052		22 59 40		0,017307	
		11877		1 29 20		2332
12	0,00184929		24 29 0		0,019639	
		11942		1 28 50		2466
24	0,00196871		25 57 50		0,022105	
		12014		1 28 19		2603
36	0,00208885		27 26 9		0,023708	
		12087		1 27 46		2733
48	0,00220972		28 53 55		0,027441	
		12163		1 27 14		2862
4 0	0,00233135		30 21 9		0,030303	
		12248		1 26 37		2989
12	0,00245383		31 47 46		0,033292	
		12332		1 26 3		3111
24	0,00257715		33 13 49		0,036403	
		12424		1 25 24		3233
36	0,00270139		34 39 13		0,039636	
		12519		1 24 45		3351
48	0,00282658		36 3 58		0,042987	
		12616		1 24 6		3465
5 0	0,00295274		37 28 4		0,046452	
		12720		1 23 25		3577
12	0,00307994		38 51 29		0,050029	
		12826		1 22 44		3686
24	0,00320820		40 14 13		0,053715	
		12938		1 22 1		3793
36	0,00333758		41 36 14		0,057508	
		13051		1 21 16		3897
48	0,00346809		42 57 30		0,061405	
		13172		1 20 33		3995
6 0	0,00359981		44 18 3		0,065400	

TABLE VII.

A Table of the Mean Motion, Anomaly, *and* Diſtance *from the Sun, computed for the* ELLIPTIC ORBIT *of the Comet*, 1682, concluded.

Anamoly of the Eccentric.		Mean Motion of the Comet.	Difference.	Angle from the Perihelion.			Differenee.			Logarithm of Diſtance from the Sun.	Difference.
°	'			°	'	''	°	'	''		
6	0	0,00359981	13295	44	18	3	1	19	48	0,065400	4093
	12	0,00373276	13422	45	37	51	1	19	3	0,069493	4183
	24	0,00386698	13553	46	56	54	1	18	16	0,073676	4276
	36	0,00400251	13689	48	15	10	1	17	31	0,077952	4363
	48	0,00413940	13829	49	32	41	1	16	43	0,082315	4447
7	0	0,00427769	13972	50	49	24	1	15	56	0,086762	4530
	12	0,00441741	14120	52	5	20	1	15	8	0,091292	4606
	24	0,00455861	14271	53	20	28	1	14	20	0,095898	4682
	36	0,00470132	14427	54	34	48	1	13	32	0,100580	4753
	48	0,00484560	14587	55	48	20	1	12	43	0,105333	4824
8	0	0,00499147	14751	57	1	3	1	11	55	0,110157	4889
	12	0,00513898	14921	58	12	58	1	11	7	0,115046	4953
	24	0,00528819	15093	59	24	5	1	10	19	0,119999	5014
	36	0,00543912	15267	60	34	24	1	9	29	0,125013	5070
	48	0,00559179	15447	61	43	53	1	8	41	0,130083	5128
9	0	0,00574626	15633	62	52	34	1	7	53	0,135211	5178
	12	0,00590259	15821	64	0	27	1	7	3	0,140389	5229
	24	0,00606080	16015	65	7	30	1	6	16	0,145618	5276
	36	0,00622095	16210	66	13	46	1	5	27	0,150894	5322
	48	0,00638305	16410	67	19	13	1	4	38	0,156216	5363
10	0	0,00654715	16616	68	23	51	1	3	51	0,161579	5403
	12	0,00671331	16825	69	27	42	1	3	3	0,166982	5440
	24	0,00688156	17037	70	30	45	1	2	17	0,172422	5476
	36	0,00705193	17254	71	33	2	1	1	30	0,177898	5509
	48	0,00722447	17474	72	34	32	1	0	43	0,183407	5539
11	0	0,00739921	17700	73	35	15	0	59	56	0,188946	5568
	12	0,00757621	17929	74	35	11	0	59	11	0,194514	5595
	24	0,00775550	18162	75	34	22	0	58	24	0,200109	5619
	36	0,00793712	18399	76	32	46	0	57	41	0,204728	5643
	48	0,00812111	18640	77	30	27	0	56	55	0,211371	5663
12	0	0,00830751		78	27	22				0,217034	

PART III.

Containing the Proceſs of COMETARY CALCULATION; *or a Solution of all the Problems for finding the* Place *and* Diſtance *of a Comet both from the* Sun *and* Earth; *the* Longitude *and* Latitude *of a Comet for any given Time; the* Magnitude *of the Head,* Nucleus, *and Tail of a Comet. The whole exemplified in the Comet which will next return.*

PROBLEM I.

To find the apparent Place of the SUN, *and the true Place of the* EARTH *in the* ECLIPTIC, *for any given Time.*

PRECEPTS *of Calculation.*

1. FROM Table IV. take out the Numbers under the *Mean Motion of the Sun* for the *radical* and *current Year*; the Month, and Days; the Hour, Minute, *&c.* and collect them all into one Sum; this will be the *mean Place* of the Sun.

2. Under the Title of *Mean Motion of Perihelion*, take out the Numbers agreeing to the given Time as before, and add them into one Sum, which will be the *mean Place of the Perihelion.*

3. From the Place of the Sun, ſubduct that of the *Perihelion*, and the Remainder will be the Sun's *mean Anomaly.*

4. With this Anomaly enter Table V. and take out the Number correſponding thereto; this is the *Equation of the Sun* (or properly, of the Earth's Orbit.)

5. This Equation *added to* or *ſubtracted from* the Sun's *mean Place* (as the Table directs) will give the *Sun's apparent Place* in the Ecliptic.

6. The Part of the Ecliptic oppoſite to the Sun's Place, is the *true Place of the Earth in its Orbit.*

EXAMPLE.

Let it be required to find the true Place of the Sun and Earth for *Auguſt* 30th, 7^h 42', *Anno* 1682, Old Style.

	M. Mot. of the Sun.				M. Mot. of Perihel.				
	s	°	'	"	s	°	'	"	
Rad. 1681 —	9	20	34	46	3	7	23	30	
Cur. Year 1—	11	29	45	40				50	
Aug. 1. —	6	29	56	34				29	
Day 29 —	0	28	35	2				4	
Hour 7 —		0	17	15					
42' —			1	43	3	7	24	53	
					5	19	11	00	
M. Mot. of ☉	5	19	11	00					
Equat. ſub. —		1	50	23	2	11	46	07	M. Anom.
☉ Place —	5	17	20	37					
Add —	6	0	0	0					
The Sum is	11	17	20	37	the Earth's true Place.				

PROBLEM II.

To find the Diſtance of the Earth *from the* Sun *for any Time.*

PRECEPTS.

1. Find the Sun's mean Anomaly for the given Time, and the Place of the Earth, by Prob. I.

2. With this Anomaly enter Table VI. and take out the Logarithm correſponding to the Sign and Degree of the given Anomaly.

3. If great Exactneſs be required, the proportional Part of the Logarithm for the Minutes muſt be found by the Rule of Three, by taking the Diſtance between the Logarithm of the given Degree and that of the next greater, and then ſay, *As* 60' *is to this Difference,*

ſo is the given Number of Minutes to the proportional Part; which is to be added to the firſt Logarithm, and that Sum is the Logarithm of the Earth's Diſtance required.

4. With this Logarithm you enter the common Table of Logarithms, and the Number which you find againſt the Logarithm neareſt to it, is the Diſtance of the Earth in ſuch Parts whereof the mean Diſtance contains 1000000, *&c.* And if great Exactneſs be neceſſary, you muſt work by Proportion as above directed.

EXAMPLE.

It is required to find the Diſtance of the Earth from the Sun, on *Auguſt* 30th, $7^h\ 42'$, *Anno* 1682, O. S.

The Sun's mean Anomaly for that Time is found to be $2^s\ 11^\circ\ 46'\ 7''$.

In Table VI. under 2 Signs on the Top and againſt 11° on the Side, is the Logarithm 1,002495; the Difference beween this and that anſwering to the next greater Degree, is 120; then ſay, as 60 : 120 :: 46 : 92; which ſubtracted from 1002495, leaves 1,002403 for the Logarithm of the Earth's true Diſtance.

In the common Table of Logarithms the neareſt Logarithm to this will be found 1.002209, againſt which is the Number 10051; which ſhews the Earth's Diſtance is here but little more than the mean Diſtance 10000. But to be quite exact you muſt take the proportional Parts, which will give the Diſtance to a greater Number of Places.

PROBLEM III.

Having the Perihelion Diſtance *of a Comet, to conſtruct its Orbit.*

PRECEPTS.

1. Draw any Right Line A B indefinitely, in which let F V be taken equal to the given *Perihelion Diſtance* of the Comet. Fig. IV.
2. In the ſame Line take V A equal to V F.
3. In the Part V F continued, take a ſufficient Number of Points B, B, B, B, *&c.* about as near to each other as in the Figure.
4. Thro' theſe Points draw parallel Lines indefinitely, B C, B C, B C, *&c.* all perpendicular to the Line V F.
5. Then take the Diſtance A B of each Line from the Point A in your Compaſſes, and ſetting one Foot in the Point F, with the other croſs

croſs each parallel Line B C in C, and you will thus obtain the ſeveral Points C, C, C, *&c.* in thoſe Lines reſpectively.

6. With an even Hand draw a Curve thro' all thoſe Points C, C, C, *&c.* and it will be the Curve of that *Parabola* which the Comet deſcribes about the Sun in its *Focus* F.

N. B. Only one half of the Curve is drawn here, becauſe it is eaſy to underſtand that by continuing the parallel Lines; the ſame Thing is to be done on the other Side.

Note alſo, that if this Curve be firſt drawn upon *Paſtboard*, the *Parabola* may be eaſily cut out, and by the Edge of that Parabola the Comet's Orbit may at any Time be drawn upon a clean Paper, with a Pencil or *Drawing-Pen*.

Note, thirdly, that the dotted Line F E which paſſes thro' the Point F to the Curve, is equal to twice F V, or to F A.

PROBLEM IV.

The Perihelion, Time, *and* Diſtance *of a Comet being known, to find the* Place *of a Comet in its Orbit, or its true Anomaly for any given Time.*

PRECEPTS.

1. Multiply the Logarithm of the Perihelion Diſtance by 3.

2. Divide that Product by 2, (or take the half of it,) which is a Logarithm to be uſed by and by.

3. To or from the Time of the Perihelion add, or ſubſtract, the given Time, as it may be found neceſſary.

4. The Sum or Difference let be expreſſed in Days and *decimal Parts* of a Day, by the Means of Table III.

5. From the Logarithm of this Number of Days, take the Logarithm mentioned in Precept 2d, the Remainder is the Logarithm of a Number of Days and decimal Parts of a Day, whoſe Number will be found in a Table of Logarithms.

6. Let this Number of Days be ſought in Table II. in the firſt Column.

7. Againſt this Number in the ſecond Column is the *true Anomaly* of the Comet expreſſed, in Degrees, Minutes, and Seconds, which you muſt take out, and make Allowance for the decimal Parts of a Day, as uſual.

8. Laſtly, with the *Protractor* ſet this Angle off from the Perihelion on one Side or other, as the given Time is before or after that of

the Perihelion, and the Line drawn will cut the Orbit of the Comet in the Point where the Comet is at that Inſtant.

EXAMPLE.

Let the Place of the Comet of 1682 be required in its Orbit for *Auguſt* 30th, $7^h\ 42'$, equal Time.

The Logarithm of its Perihelion Diſtance is — 9,765877
Which multiply by — — — 3

Divide the Product — — — 9,297631
By — — 2

This Half is the Logarithm — — 9,648815

The Time of the Perihelion is — *September* $4^d\ 7^h\ 39'$
The given Time is — — *Auguſt* 30 7 42

Which precedes the Perihelion by — 4 23 57

Note, As there wants only 3′ of 5 Days, 'tis not neceſſary in this Caſe to conſult the *decimal Table* for ſo ſmall a Part.

Therefore from the Logarithm of 5 Days — 0,698970
Take the above mentioned Logarithm — 9.648815

Remains the Logarithm of Days, — 11,224=1.050155

In Table II. againſt 11 Days in the firſt Column, is, in the ſecond Column of true Anomaly $15^\circ\ 9'\ 14''$
Againſt 12 Days is — 16 29 43

The Difference is — 1 20 29

That is 80′½, then ſay, As 1000 : 224 :: 80′,5 : 18′.

Therefore the true Anomaly is $\left\{\begin{matrix}15^\circ\ 9'\ 14''\\ 18\end{matrix}\right\}=15^\circ\ 9'\ 32''$

Then from the Perihelion S P ſet off with the Protractor the Angle PSQ=15° 9′½, and the Line S Q will cut the Comet's Orbit in the Point Q which is the Place of the Comet at the given Time.

And in this Manner was the Place of the Comet computed for every 5 Days from the Perihelion P, to each Node; as you find it in the *large Print of the Comet*, which I lately publiſhed.

PROBLEM V.

Having given the true Anomaly *of a Comet, or the* Place *in its Orbit, to find its* Diſtance *from the Sun.*

PRECEPT.

From the Logarithm of the Perihelion Diſtance in Table I. ſubduct the double Logarithm of the Coſine of half the given Anomaly; There will remain the Logarithm of the Diſtance required.

EXAMPLE I.

Let it be required to find the Diſtance of the Comet, 1682, from the Sun at its Deſcending ☋, the Anomaly P S ☋ being 71° 36′.

The half of 71° 36′ is 35° 48′; the Complement of that is 54° 12′, and the Logarithm of its Sine	9.909055
And the Double thereof is	9.818110
Then from the Logarithm of the Perihelion Diſtance	9.765877
Subtract the above Logarithm	9.818110
Remains the Logarithm of the Diſtance	0,8867=9.947767

That is the Diſtance of the Comet S ☋ at its deſcending Node ☋ is 8867 ſuch Parts, whereof the Diſtance of the Earth S B contains 10000.

N. B. If the Comet's Anomaly be 90°, or a Right Angle, then the Diſtance of the Comet is juſt twice the Perihelion Diſtance. See Note 3d of Prob. III.

EXAMPLE II.

The Anomaly of the Comet 1682, being $15^\circ\ 9'\frac{1}{2}$ preceding the Perihelion, required the Diſtance from the Sun.

Half the given Anomaly is, $7^\circ\ 34'\frac{3}{4}$ or $7^\circ\ 35'$, the Complement of which is, $82^\circ\ 25'$.

The Logarithm of its Sine	9,996185
The Double of which	9,992370
The Logarithm of Perihelion Diſtance	9,765877
The Difference is the Logarithm of 0,5936 =	9,773507

Therefore making the Angle $PSQ = 15^\circ : 9'\frac{1}{2}$, then will the Diſtance of the Comet $SQ = 5936$ of ſuch Parts as the mean Diſtance of the Earth contains 10000.

PROBLEM VI.

To find the perpendicular Diſtance of the Comet from the Line of Nodes.

PRECEPTS.

1. From the Place of the Comet Q let fall the Perpendicular QN on the Line of Nodes ☊ ☋.
2. Then in the Right angled Triangle QSN, there being known $SQ, = 5936$, and the Angle $NSQ = PS☋ + PSQ = 71^\circ\ 36' + 15^\circ\ 9'\frac{1}{2} = 86^\circ\ 45'\frac{1}{2}$, to find the Side QN; ſay

As Radius - - - - - - - -	10,000000
To the Sine of $QSN = 86^\circ\ 45'$ - -	9,999301
So is the Side $SQ = 5936$ - - -	3,773507
To the Side $QN = 5926$ - - -	3,772808

PROBLEM VII.

To find the perpendicular Diſtance of the Comet from the Plane of the Ecliptic.

PRECEPTS.

1. From the Place of the Comet Q, let fall a Perpendicular QD on the Plane of the Ecliptic, and draw ND.

2. Then in the Right angled Triangle N Q D, there being given the Diſtance N Q = 5926, and the angle of the Inclination of the Orbit (by Table I.) Q N D = 17° : 56′, to find the Side Q D, ſay

As Radius - - - - - - - - - - -	10,
To the Sine of the Angle Q N D = 17° 56′	9,488424
So is the Side N Q = 5926 - - -	3,772808
To the Side Q D = 1825 - - - - -	3,261232

PROBLEM VIII.

To find the Heliocentric Latitude *of the Comet.*

PRECEPT.

In the Right angled Triangle Q S D, there are given the Sides Q S and Q D, to find the Angle Q S D, or the Comet's *Heliocentric Latitude*; therefore ſay,

To the Side - - - - S Q = 5936	3,773507
Is to Rad. — — —	10
So is the Side - - - Q D = 1825 =	3,261232
To the Angle - - — Q S D = 17° 54′	9,487725

PROBLEM IX.

To find the Comet's Curtate Diſtance from the Sun.

PRECEPT.

In the Right angled Triangle Q S D, there is known the angle Q S D = 17° 54′, and the Side Q D = 1825; to find the Side S D, ſay,

As the Tangent of the Angle Q S D = 17° 54′	9,509191
To Radius - - - - - - - -	10
So is the Side - - - - - - Q D = 1825	3,261232
To the Side - - - S D = 5650	3,752041

PRO-

PROBLEM X.

To find the Diſtance of the projected Place of the Comet in the Plane of the Ecliptic, from the Line of Nodes.

PRECEPT.

In the Right angled Triangle Q N D, there is known the Side Q D = 1825, and the Angle Q N D = 17° 56′, to find the Side D N; ſay,

As the Tangent of Angle Q N D = 17° 56′ 9,510054
To Radius - - - - - - - 10
So is the Side - - - Q D = 1825 3,261232

To the Side - - - D N = 5639 3,751178

PROBLEM XI.

To find the Heliocentric Place of the Comet in the Ecliptic.

PRECEPT.

In the Right angled Triangle S N D, there are known the Sides S D and D N, to find the Angle N S D; then ſay,

As the Side - - - D S = 5650 3,752041
To the Side - - - N D = 5639 3,751178
So is Radius - - - - - 10

To the Sine of the Angle N S D = 86° 23′ = 9,999137

	s	°	′	″
That is in Signs — —	2	26	23	00
The Deſcending Node is in ♏ —	7	21	16	30
The Sum is — — —	10	17	39	30

Therefore the Heliocentric Longitude of the Comet in the Ecliptic, or its Place ſeen from the Sun, is in ♒ 17° 39′ 30″

PROBLEM XII.

To find the Geocentric Place, *or* Elongation *of the Comet from the Sun.*

PRECEPT.

	s	o	′	″
1. From the Place of the Earth T —	11	17	21	30
Subduct the Place of the Comet —	10	17	39	30
There remains the Angle T S D — =		29	52	

2. Then in the Oblique Triangle D S T there are known the Sides S T and S D; and the Sum of the Angles at T and D, to find thoſe Angles. Therefore ſay,

As the Sum of the Sides T S + S D = 157032 5,195908
'Tis to their Diff. T S — S D = 43032 4,633771
So is the Tang. of half the Sum of the unknown Angles $\left.\right\} \frac{T+D}{2} = 75° : 4'$ 10,573973
15,207744
To the Tang. of half their Diff. $\frac{T-D}{2} = 46° \ 12'$ 10,011836

Now to the half Sum — — 75° 04′
Add the Half Difference — 46 12
The Sum is the Angle at D = — 121 16
And their Difference is the Angle T = — 28 52
To which add the Sun's Places — 5s 17° 21′
The Sum is — — — — 6 16° 13′ or the Comet ſeen from the Earth will appear in 16 : 13′ of ♎.

Now the obſerved Longitude in the Table is ♎ 15° 34′ 42′, which is leſs than the Place here computed by 38′; whereas Dr. *Halley*'s Difference is but 1′ 16″; but from what Tables he made his Computations I know not; for by the Doctor's own Tables I find the Error much greater than by thoſe which I have here given, which upon all other Occaſions I have found to come neareſt the Truth.

PRO-

PROBLEM XIII.

To find the Geocentric Latitude *of the Comet.*

PRECEPTS.

1. To find the Side T D in the Triangle T D S, ſay;

As the Sine of the Elongation S T D = 28° 52′	9,683743
Is to the Side — — S D = 5650	3,752041
So is the Sine of the Angle T S D = 29° 52′	9,697215
	13,449256
To the Side —— —— T D = 58279	3,765513

2. Then in the Right angled Triangle T Q D, there is known the Side Q D and T D to find the Angle Q T D.

Say, as the Side — — T D = 58279	3,765513
is to Radius - - - - - -	10.
So is the Side - - Q D = 1825	3,261232
To the Tang. of the Angle Q T D = 17° 23′	9,495719

The Latitude of the Comet ſeen from the Earth, by Obſervation is but 17° 24′ 56″, according to the Table; therefore the Theory agrees with Obſervations for the Latitude within 2 Minutes. By the Doctor's Computation it is within 1 Minute.

PROBLEM XIV.

To find the true Diſtance of the Comet from the Earth.

PRECEPT.

In the Right-angled Triangle T Q D, there are given the Side Q D and the Angle at T to find the Side T Q. Wherefore ſay,

As the Sine of the Angle - Q T D = 17° 23′	9,475327
Is to the Side - - - Q D = 1825	3,261232
So is Radius - - - - - -	10
To the Diſtance ſought - - T Q = 6108	3,785905

Suppoſing therefore the Diſtance of the Sun to be about 80000000 Miles, then by Analogy, ſay, as 10000 : 80000000 :: 6108 : 48864000, the Number of Miles contain'd in the *Comet's Diſtance from the Earth.*

PROBLEM XV.

To find the Place, or mean Anomaly, of a Comet in its true Elliptic Orbit, for a given Time.

PRECEPTS.

1. Let the given Time before or after the Perihelion be expreſs'd in decimal Numbers, and find its Logarithm.
2. Add this Logarithm to the conſtant Logarithm of the Diurnal mean Motion 6,357636, and the Sum will be the mean Motion of the Comet for the given Time.
3. Seek in the ſecond Column of Tab. VII, the mean Motion neareſt the given One, and the Angle from the Perihelion againſt it in the fourth Column.
4. Then by the Difference in the third Column, find the proportional Part of the Anomaly, which added to the former will give the true Anomaly or Place of the Comet in its Orbit.

EXAMPLE.

Let the Place of the Comet of the Year 1682, be required in its Elliptic Orbit for 5 Days 13 Hours 40 Minutes before the Perihelion.

This Space of Time in Decimals is 5,5694 whoſe Logarithm is — —	0.745811
to which add the Logarithm — —	6.357636
The Sum is the Logarithm — — —	7.103447

The Number belonging to which is, 0.00126896, the mean Motion of the Comet for the given Time, againſt $2^s\ 12'$ of the Eccentric in the firſt Column.

From this mean Motion — —	0.00126896
Deduct the next leſs in the Table —	0.00126120
There will remain — — —	776

The Angle from the Perihelion in the Table is, 16° 57′ 55″, then the Difference of the mean Motion for 2° 12′ and 2° 24′, is 11655 in the third Column. And the Difference of the Angles from the Perihelion is 1° 31′ 4″; wherefore ſay, as 11655 : 1° 31′ 4″ :: 776 : 6′ 3″; which added to the tabular Angle 16° 57′ 55″, gives 17° 3′ 58″ for the true Anomaly of the Comet required.

N. B. This Anomaly was before found leſs for the *parabolic* Orbit, (ſee *Prob.* IV.) but it muſt be remembered, that given Time was *Auguſt* 30^{D}: 7^{h}: 42′, which was but 5 Days before the Perihelion according to Dr. *Halley*'s own Tables; but when the Doctor calculates this Anomaly for the ſame Time in an Elliptic Orbit, he makes this Time $5\frac{1}{2}$, and in half a Day there is juſt the Difference in the Place of the Comet as is found in theſe two Problems. Indeed it is no unuſual Thing for the Doctor's Tables and his Calculations to diſagree.

PROBLEM XVI.

To find the Diſtance of the Comet from the Sun at any given Time within the Compaſs of the Table, for an Elliptic Orbit.

PRECEPTS.

1. Find the mean Anomaly (by the foregoing Problem) for the given Time.
2. Againſt that which is next leſs in the Table, take the Logarithm for the Diſtance from the Sun correſponding to it, to which find the proportional Parts for the true Ratio.
3. Add this to the conſtant Logarithm 9,765877 of the Perihelion Diſtance of this Comet; and the Sum will be the Logarithm of the true Diſtance of the Comet from the Sun as required for the given Time.

EXAMPLE.

Required the Diſtance of the Comet of the Year 1682, for 5 D. 13 h. 40′ from the Time of the Perihelion.

The mean Motion of the Comet for that Space of Time is found by the laſt Prob. to be 0,00126896; the next leſs to this in the Table VII. is 0,00126120, the Difference is 776; and the Difference between the next leſs and next greater is (the ſame as before)

fore) 11655, and the Difference of the Logarithms is 1760, in the laſt Column: Wherefore ſay by Analogy;

As 11655 : 1760 :: 776 : 117, theſe Parts added to the Logarithm 0,009396 Diſtance from the Sun correſponding to the next mean Motion in the Table, gives 9,775390 which is the Logarithm of the Diſtance required, *viz.* 59620, which ought to exceed the Diſtance found by Prob. V. (which was 59360) as this Diſtance anſwers to 5$\frac{1}{2}$ Days, and that to 5 only.

However if when the Comet appears, *the Elements of its Motion be well determined* from Obſervation, this Table of Dr. *Halley*'s will be found extremely exact, while the Anomaly does not exceed 78 Degrees, which is as long as ſuch a Table can be of Uſe. And is much more genuine, tho' not ſo general, as that of Mr. *de la Caille* for the Motion in a Parabola. This Table VII. will ſerve only for the Comet of 1682, which we are now in daily Expectation of; for any other Comet, a new Table of Elliptic Motion may be conſtructed by thoſe who have Leiſure, and will be at the Trouble of it. When the Anomaly and Diſtance from the Sun are found, every Thing elſe is computed as in the foregoing Problems.

PROBLEM XVII.

To find the Length of the Comet's Tail.

PRECEPTS.

1. Let Q be the Place of the Comet when an Obſervation was made of the Angle Q T L under which the Tail Q L was ſeen at the Earth T.

2. Produce S Q till it meets with T M produced in M; then will the Angle T Q M = Q T S + T S Q, both which are known from the Theory, but the Angle Q T M is known by Obſervation; therefore the Angle M is alſo known.

3. The Angle L Q M by which the Tail deviates from the Oppoſition of the Sun, is known by Obſervation; therefore the Angle Q L M is known, and alſo the Angle Q L T, and the Angle L Q T.

4. Therefore in the Triangle Q L T, there are known the two Angles at L and Q, and the Side T Q to find the Side L Q, which is the Length of the Tail required.

Note, having found the Side T L the Width or Diameter of the Tail at L is alſo eaſily found.

Mr. *Flamſted* has left us no proper Obſervation of the Angle which the Tail of the Comet ſubtended on the 30th of *Auguſt*, nor could he, by Reaſon of the Light of the Moon, as we find in the *Hiſtoria Cæleſtis*. Therefore we can't illuſtrate this Problem by Example for that Day, as we have done in all the others. But if the curious Reader will calculate the Place of the Comet, and its Diſtance from the Earth (by the foregoing Problems) for *Auguſt* 22, at eight at Night, he might find the Length of the Tail then, as it ſubtended at that Time an Angle of *ten Degrees.*

PROBLEM XVIII.

To find the Magnitude of the Atmoſphere, and Nucleus *of the Comet.*

PRECEPTS.

For this Purpoſe the Angle which the Head of the Comet ſubtends at the Earth muſt be carefully meaſured with a Micrometer; this was done by Mr. *Flamſted* for the preſent Comet on *Auguſt* 20th, at 9 o'Clock, when he found it juſt two Minutes of a Degree, and the *Nucleus* about 12″. The Diſtance of the Comet ſrom the Earth was leſs than T Q on the 30th in Proportion of 7$\frac{1}{4}$ to 10, or 725 to 1000. Therefore as a 1000 : 725 : : 120′ 88″; hence the Comet Q at the Diſtance T Q would ſubtend an Angle only of 1′ 28″; wherefore ſay,

As Radius	— — — —		10
To the Sine of	— — —	1′ 28″	6,604206
So is the Diſtance	—	T Q = 6108	3,785905
To the Diameter of the Head	—	= 2,4552	0,390111

To reduce which to Miles ſay, as 10,000 : 80000000 : : 2,4553 : 19642,4; That is, the Diameter of the Head is 19 *thouſand* 6 *hundred and* 42$\frac{1}{2}$ *Miles* nearly; therefore we may judge the Head of this Comet to be about 15 Times as big as the Earth.

The Diameter of the *Nucleus* is about $\frac{1}{10}$ of that of the Head, *viz.* 1964$\frac{1}{4}$ Miles, which is nearly equal to that of the *Moon.*

SCHOLIUM.

But from hence it is certain there is a great Difference in the Magnitude of Comets; for by the ſame Proceſs of Calculation, I computed the Magnitude of the Comet of the Year 1683, which *Hevelius* obſerved on *Auguſt* 6th, and meaſuring it, found it ſubtended an Angle of 6′ 5″, including the *Coma*. At that Time the Diſtance of the Earth from the Comet was 5870,6 therefore by this Problem the Comet's Head will be found 83104 Miles in Diameter, which is more than ten Times as great as the Diameter of the Earth, whence it appears, the whole Bulk of that Comet's Head was much more than 1000 Times as big as our Earth. And the *Nucleus* or ſolid Body of the Comet at leaſt as big as that of the Globe of the Earth itſelf. And it is to be hoped that for the future, the Students in Aſtronomy will never let a Comet paſs without meaſuring its apparent Diameter whenever it can be done with Exactneſs.

PART IV.

The Method of delineating the VISIBLE PATH *of a Comet among the Stars, on the Surface of the* CELESTIAL GLOBE; *and alſo to draw its real Trajectory by Protraction and Calculation; with a Computation of the prodigious Velocity of the Comet of* 1680, *and of its Tail.*

THE Method of drawing on a Globe the Tract of a Comet, or its apparent Path amongſt the Stars in the Heavens, is both eaſy and pleaſant ; as you will this Way be able to foreſee and ſhew what Courſe the Comet will take during the Time of its Appearance, and conſequently in what Part of the Heavens it may be expected at any Time aſſigned.

In order to this it will be neceſſary to make three Obſervations on the Place of a Comet at its firſt Appearance pretty exactly, at the Diſtance of a Day or two from each other, as the Weather, *&c.* will permit. The practical Method moſtly uſed for this Purpoſe is, to ſtretch a Thread over the Comet, and to move it this way and that till it lies over the Comet and two known fixed Stars ; and after this, moving the Thread into another Poſition, ſo as it may bring the Comet into a right Line with two other fixed Stars, which will be found not very difficult, among ſuch a great Number of Stars. Having therefore the Poſition of the Comet with reſpect to theſe Stars in the Heavens, by finding the ſame Stars on the Surface of the Globe, and laying the Quadrant of Altitude over each two reſpectively, and drawing Lines between them with a Pencil, thoſe Lines will interſect each other in the Place of the Comet in each Obſervation, and thus the Places of the Comet may be aſſigned on the Surface of the Globe for any Number of Obſervations, and a Circle paſſing thro' two or more Places, thus marked on the Globe, will be the future Way of the Comet.

But the beſt Way of finding at once the Place of a Comet on the Globe, is by an *Azimuth Quadrant*, which gives the *Altitude* and *Azimuth* of the Comet at one Obſervation; that is, its Height above the Horizon and Diſtance from the *South* or *North* Points, which is all that is required to find the Place of the Comet immediately on the Surface of the Globe: For having rectified the Globe to the Latitude of the Place, and fix'd the Quadrant of Altitude to the Zenith on the Meridian, you place it to the Azimuth on the Horizon, and at the Degree of Altitude on the Edge of it, is the Place of the Comet required. And ſo very eaſy and expeditious is this Method, that it will not require more than three Minutes, to make the Obſervation, and find the Place of the Comet on the Globe.

When two or three Places of the Comet are thus marked on the Globe, a great Circle is to be drawn thro' them, which is thus done. Let one of the Poles be raiſed or depreſs'd, and the Globe turn'd round, till the Places mark'd coincide with the Horizon, or touch it all at the ſame Time, then with a Pencil draw a great Circle along the Surface of the Globe by the Horizon, and that will be the Path of the Comet required, or its viſible Way in the Heavens.

In the Points where this Circle interſects the Ecliptic, will be the *Nodes of the Orbit* of the Comet; and the Angle contain'd between this Circle and the Ecliptic will be the *Inclination of the Comet's Orbit* to the Plane of the Ecliptic; the Quantity of which is readily meaſured at the 90th Degree from the Node on the Quadrant of Altitude fix'd over the Pole of the Ecliptic, and laid on the ſaid 90th Degree.

After this Manner the Place of the Comet (for every Night it can be ſeen) may be repreſented or protracted on the Surface of the Globe; and thereby its *Longitude*, *Latitude*, *Velocity* of Motion, and other Things relative to it, may be eaſily defined. And the ſame Things which are done on the *Globe*, are to be perform'd on the *Planiſphere* in which the fixed Stars are laid down.

But if a *graphical Delineation* or Calculation be required, and the Method of drawing *in Plano* that Part of the Comet's Orbit which is determined by theſe Obſervations, it may be done with greater Exactneſs than on the Globe, and in a more general and extenſive Manner, as from the viſible Way on the Globe we can deſcribe its real Trajectory in the Heavens, at leaſt ſo far as it may be conſider'd as rectilineal, and defined by Obſervations made within ſhort Intervals of Time.

And firſt let us proceed to a trigonometrical Calculation on the Surface of the Globe. And with regard to the Comet under Conſideration, ſuppoſe the Place of the Earth at the firſt Appearance of the Comet, was at T; on the Point T as a Center and with a Radius equal to that of the Globe (on which the Comet's Orbit was drawn) deſcribe the Circle N D V, repreſenting that of the Comet's Orbit on the Globe. And let N H X be the *Ecliptic*, which the Path of the Comet interſects in the Point or Node N; and let D and G be two Places found by Obſervation; then through D and G draw the Circles of Latitude D H and G L; and alſo the great Circle G H. Fig. VI.

Then in the ſpherical Triangle G H L, right Angled at L, you have given the Side G L (the *Latitude* of the Comet at G) and L H, the Difference of the Longitude of the Places of the Comet at G and D; from whence the Side G H will be known.

Again in the Triangle G H D you have all the Sides given; *viz.* G H juſt now found; D H the Latitude of the Comet at D; and G D, the obſerved Diſtance of the Places, and therefore the Angle H D G will be known, and of Courſe its Complement H D N.

Laſtly, in the Triangle D N H, there is known, beſides the right Angle at H, the Side H D, and the Angle H D N; therefore the Side H N will be found, *viz.* the Diſtance of the Point H from the Nodes; and the Angle H N D, which meaſures the *Inclination* of the Way of the Comet to the Ecliptic.

But now in Order to a *graphical Delineation* of the *real Path* of the Comet, and to find the ſeveral Places in its Orbit for the Times of Obſervation, it will be neceſſary to premiſe the following,

LEMMA.

Three right Lines T A, T B, T D, being given in Poſition, drawn from the ſame Point and lying in the ſame Plane, from the Point A given in any one of them (as in T A) to draw the right Line A C, whoſe Parts A E, E C, intercepted between the ſaid right Lines, ſhall have a *given Ratio*, *viz.* that of R to S, or ſuppoſe 3 to 5. Fig. V.

From the given Point A draw any how the right Line A B to croſs T B in the Point B, and continue it indefinitely. In this Line take B F to A B in the given Ratio of S to R, or 5 to 3, (which is done by the Sector eaſily;) thro' the Point F draw F C parallel to B T meeting with T D in C. Then by Reaſon of the ſimilar Triangles A B E, A F C, you have A E : A B : E C : : B F : R : : S : 3 : 5. therefore the Line A C is divided in E, as required.

The Angle T A C, and the Length of A C in reſpect of A T are alſo to be found from the above *Data* by a common Skill in Trigonometry. Therefore to apply this Caſe to Practice, ſince T is the Place of the Earth in its Orbit, let A, B, and D be three obſerved Places of the Comet in its viſible Way thro' the Heavens, put R for the Time between the Obſervations at A and B, and S for the Time between thoſe at B and D; and draw the Line T A, T B, T D. And by the foregoing *Lemma* let the right Line A O be ſo drawn thro' A that its Parts A E and E C intercepted between the two right Lines T A, T B, and T B, T D, may have the Proportion of R to S, or of the Times in which each two Obſervations were made: This Line will be nearly the Comets true Path in the Syſtem, eſpecially in any conſiderable Diſtance from the Perihelion P, where a ſmall Portion of a *Parabola* or an *Ellipſis*, is not ſenſibly different from a *right Line*. Fig. VI.

In ſuch a Caſe alſo the Motion of the Comet is nearly equable, and conſequently the Spaces paſſed thro' are proportional to the Times in which they are deſcribed. But A E is to E C as the Time in which the Comet is ſeen to move from A to B among the Stars to the Time it takes to move from B to D; and this Ratio can be found in no other right Line drawn from A but the Line A O. This therefore is very nearly the Comet's Trajectory.

As the Poſition of the Line A O, or the Angle it makes with A T, is known by the above *Lemma*, if you draw T P perpendicular to A C, the Comet in the Point P will be neareſt the Earth T, which Point is therefore called the *Perigæum* of the Comet. Produce T P to G, and that will be its viſible Place among the Stars on the Globe when it is neareſt to the Earth.

To find the Place of the Comet in its *Perigæum*, or when it is at P; in the right-angled Triangle A P T, the Sides A T and Angle T A P are known, by which you will find the Sides A P and T P, and the Angle A T P, whoſe Meaſure is the Arch A G; wherefore the Place of the Comet among the fixed Stars is known when *in Perigæo*.

The Time of its being there is alſo eaſily found; for ſince the Spaces paſſed thro' A C, A P, are as the Times; but A C and A P are known in reſpect of A T ; alſo the Time of paſſing thro' A C is known by Obſervation. Therefore as A C is to A P ſo is the Time of paſſing thro' A C to the Time of paſſing A P ; and conſequently the Time of the Comet's being in P reckoning from the Time of the firſt Obſervation in A, is known.

The viſible Place of a Comet in the Heavens is thus readily aſſigned for any given Time from the firſt Obſervation at A ; for in the Line AO, let A Q be taken to A C as the given Interval of Time to that between the Obſervations at A and D, and Q will be the Place of the Comet in its Path ; and drawing thro' Q the Line T V, the Point V will be the viſible Place of the Comet in the Heavens at the given Time.

The Velocity of a Body moving equably will be apparently leſs in Proportion as it is farther from the Eye ; that is, at twice or three Times the Diſtance, it will appear to move twice or three Times as ſlow. Hence the Velocity of the Comet at A will be to that at E in Appearance, as the Diſtance T E to the Diſtance T A ; and therefore ſince T P is the ſhorteſt or neareſt Diſtance from the Earth at T, it is plain the Velocity of the Comet will appear to be greateſt of all in the *Perigæum*, and this apparent Velocity will be eaſily eſtimated by the angular Motion of the Comet, or the Arches which it deſcribes in the Heavens in equal Times. Thus let the Space *a* A be equal to C P, they will both be deſcribed by the Comet in equal Time, but the apparent Velocities of the Comet will be as the angular Motions, that is, as the Angles *b* T A and D T G, or as the Arches *b* A and D G, which are deſcribed in the ſame Time in the Heavens.

And thus if the Time be found by Obſervation which the Comet takes to deſcribe any Part of its Trajectory A Q, and you divide the Line A Q into as many Parts as there are Days in that Time, and thro' the ſeveral Points of Diviſion you draw Lines from T to the Circle Y V, you then have the Velocity of the Comet's Motion expreſſed in thoſe diurnal Arches of the Circle N V for every Day of its Appearance.

And thus for every Day you will find the Comet's Place in its Trajectory, its viſible Place in the Heavens, its apparent Velocity, its Latitude from the Ecliptic, its Longitude from the Node, *&c.* and that very eaſily either by Protraction or Calculation, founded upon only three or four good Obſervations made at the Beginning. In this Manner an *Ephemeris* for the Comet is to be made ; and the viſible

Path or Courſe of a Comet in the Heavens may be drawn on the Surface of the *Celeſtial Globe* with pleaſure.

I ſhall conclude this Treatiſe with ſhewing the young Student of *Cometary Philoſophy*, how he may eſtimate the real Velocity of Comets in their Perihelion, and alſo that of their Tails when their Length is known; and exemplify this Matter by an Inſtance of the Comet of the Year 1680, the moſt wonderful (in this Reſpect as well as in all others) of all the Comets in the Syſtem.

Fig. VII. Let S be the Sun; *c* V *d*, the Part of the Comet's Orbit about the Sun; *e f*, a Part of the Earth's Orbit; and *a b* V, an Orbit in which we will ſuppoſe a Planet to move about the Sun at the Perihelion Diſtance S V of the Comet.

Now becauſe this Comet was obſerved to have the ſame or ſimilar Appearances with the Comet which appeared in the Year 1106, in the Reign of *Henry* I. and before, in the Year 531, and alſo before that, in the 44th Year before *Chriſt*, ſoon after *Julius Cæſar*'s Death, (as recorded by *Pliny*, and other Hiſtorian;) there is ſcarce any Doubt to be made but it was one and the ſame Comet which appeared at thoſe ſeveral Times, and at the Interval of 575 Years each.

The periodical Time therefore of this Comet being known, the tranſverſe Diameter of its elliptic Orbit will be 138296, and the conjugate Diameter 1848 of ſuch Parts as the Diſtance of the Earth from the Sun T S contains 1000.

The Perihelion S V of the Comet will be but 6 of thoſe Parts; and ſince the Sun's Diameter in *Perigæo* ſubtends an Angle of 32′, if we ſay, As Radius is 1000 ſo is the Sine of 32′ to 9,308, that will be the Diameter of the Sun expreſſed in the ſame Parts; the half of which is 4,654, which ſubtracted from 6, leaves 1,346 for the Diſtance of the Comet from the Body of the Sun; whence it appears how great the Heat muſt be, as we have before mentioned in Sir *Iſaac Newton*'s Calculation of it.

Now to compare the Velocity of this Comet with that of the Earth, and of the Comet's Tail at the Diſtance of the Earth.

Let
$ST = D = 1000$, the Diſtance of the Earth from the Sun.
$SV = d = 6$, the Diſtance of the Planet and Comet.
$v =$ Velocity of the Earth.
$V =$ Velocity of the Planet.
$\mathrm{V} =$ Velocity of the Comet *in Perihelio*.
$W =$ Velocity of the Tail at *b* in Earth's Orbit.

Then by the Laws of circular Motion, - - $v : V :: \sqrt{d} : \sqrt{\mathrm{D}}$.
Alſo from the Nature of Motion in a Parabola, $\mathrm{V} : V :: \sqrt{2} : 1$
From whence we get this Analogy - - - $v : \mathrm{V} :: \sqrt{d} : \sqrt{2\mathrm{D}}$
That is, in Numbers - - - - - - - $v : \mathrm{V} :: 1 : 18{,}2$.

Whence it appears, the Velocity of the Comet in *Perihelio* at V is more than 18 Times as great as that of the Earth; but the Velocity of the Earth in its Orbit is about 1000 Miles *per* Minute, whence the Velocity of that Comet when neareſt the Sun was at the Rate of about 18200 Miles *per* Minute.

Again, for the Velocity of the extreme Part of the Comet's Tail (which was found to exceed the Diſtance of the Earth) we have $\mathrm{V} : \mathrm{W} :: d : \mathrm{D} :: 6 : 1000$; therefore $\frac{6\mathrm{W}}{1000} = \mathrm{V} = 18{,}2\, v$; and conſequently $6\mathrm{W} = 18200\, v$, therefore $v : \mathrm{W} :: 6 : 18200 :: 1 : 3042 :: 1000 : 3042000$; that is to ſay, the Velocity of the Comet's Tail at *b* in the Earth's Orbit is at the Rate of 3 *Millions and* 42 *thouſand Miles in a Minute of Time*, which is nearly a third Part of the Velocity of Light itſelf; ſo great as to ſurpaſs not only the moſt acute Senſation of the Eye, but even the utmoſt Stretch of the human Mind. In this one Inſtance we ſee how amazing and incomprehenſible the Works of Nature are in this one Syſtem of ours. And in proportion as we ſee farther into the Scenes of Nature's Operations than *David* did, we have ſo much the more Reaſon to exclaim with him, ***How wonderful are thy Works, O Lord! in Wiſdom haſt thou made them all.***

FINIS.

BRITISH 21 JY99 MUSEUM

A
CATALOGUE
OF
Philoſophical, Optical, and Mathematical Inſtruments,

MADE AND SOLD

By *B. MARTIN*,

At his Shop, the Sign of the *Viſual-Glaſſes* and *Globe*, two Doors below *Crane-Court*, in *Fleet-Street*.

Philoſophical Inſtruments.

	l.	*s.*	*d.*
LARGE Orrery's from 40 l. to	150	0	0
Cometarium	5	5	0
Senex's Globes 28 in Diameter in Mahogany Frames with carv'd Work and ſilver'd Meridians	35	0	0
Ditto, in Wainſcot Frames	26	15	0
17 Inches, ditto	6	6	0
12 Inches, ditto	3	3	0
9 Inches, ditto	2	2	0
3 Inches, ditto in a Caſe	0	10	0
A large ſtanding Air-pump	13	13	0
Apparatus, to ditto	7	7	0
Davenport's table Air-pump	9	9	0
Apparatus, to ditto	5	5	0
Single barrel'd Air-pump	2	12	6
Apparatus, to ditto	1	1	0
Electrical Machine in Braſs, with an Apparatus Box, *&c.* from 5*l.* 5*s.* to	10	10	0
A large Pappin's Digeſter	4	4	0
Smaller, ditto	2	2	0
Beſt ſort of Barometer	1	7	0
Farenheit's Thermometer	2	2	0
Pocket Thermometer	0	12	6
Hydroſtatic Balance, Apparatus, *&c.*	1	15	0
Four models of Water-pumps in Glaſs	8	15	0
Model of a new Portable-pump	2	2	0
Ditto of a new Mercurial-pump	3	3	0
Fountain in Glaſs	2	2	0
Ditto in Copper, with Apparatus	5	5	0
A Syringe, for Injection	3	3	0
Smaller, ditto	2	2	0
Small Braſs Air-pump, with Glaſſes for Cupping	1	1	0
Hydrometer's in Ivory	0	6	0
Smaller, ditto	0	4	6
Speaking Trumpets, from 10*s.* 6*d.* to	1	11	6
Hearing Trumpets	1	1	0
Artificial Magnets, from 2*s* 6*d.* to	1	1	0

Optical Inſtruments.

	l.	*s.*	*d.*
A Three-Foot reflecting Teleſcope, mounted on a Braſs-Foot	18	18	0
A Two Foot ditto	11	11	0
Ditto, with Rack Work	14	0	0
Ditto, 18 Inches	8	8	0
Ditto, 12 Inches	5	5	0
Ditto, 9 Inches	4	4	0
Ditto, 6 Inches	3	3	0
A Nine-Foot refracting Teleſcope	3	13	6
Six Foot ditto	2	12	6
Ditto	2	2	0
Four-Foot ditto, mounted in Braſs	1	11	6
Ditto, in Horn and Vellum	1	1	0
Ditto, in Parchment	0	18	0
Three-Foot ditto, mounted in Braſs	1	5	0
Ditto, in Horn and Vellum	0	15	0
Ditto, in Parchment	0	10	0
Two Foot ditto, mounted in Braſs	0	16	0
Ditto, in Horn and Vellum	0	10	0
Ditto, in Parchment	0	6	6
Twenty-Inches, mounted in Braſs	0	13	6
Ditto, in Horn and Vellum	0	7	6
Ditto, in Parchment	0	6	0
Dalond's four Foot refractors			
Ditto three Foot			
Ditto two Foot			
Ditto			
A large Parlour Compound Microſcope, in Braſs	4	4	0
Solar Microſcope, in Braſs	4	14	6
Wilſon's Microſcope, and Apparatus	2	12	6
Ditto ſmall	1	7	0
Dr. Liburkin's opake Microſcope, and Apparatus	2	12	6
Cloth Microſcopes			
Diagonal Machines for viewing Prints	1	11	6
Ditto, on a Mahogany Foot	0	16	0
A large Book Camera Obſcura	6	6	0
Ditto, common ſort	2	12	6
Sciopticric Ball and Socket, in Braſs	0	12	6

Catalogue of Philoſophical Optical and Mathematical Inſtruments

	l.	*s.*	*d.*
Scioptric Ball and Socket, in Wood	0	7	6
An artificial Eye in Braſs	2	2	0
Ditto Small	1	1	0
Opera Glaſſes, from 5*s.* to	1	1	0
Magic Lanthorn	1	1	0
Mirror's Convex or Concave 24 Inches Diameter, hung in frames	14	14	0
Ditto, 18 Inches	7	7	0
Ditto, 15 Inches	5	5	0
Ditto, 12 Inches	2	15	0
Ditto, 10 Inches	1	16	0
Ditto, 8 Inches	1	8	0
Ditto, 7 Inches	1	1	0
Ditto, 6 Inches	0	18	0
Priſms, from 5*s.* to	1	1	0
Reading Glaſſes from 2*s* 6*d.* to	2	2	0

Mathematical Inſtruments.

Theodolites, from 5*l.* 5*s*	25	0	0
Plain Table	3	13	0
Gunter's Chain	0	7	6
Hadley's Quadrant, with Diagonal Diviſions	1	18	0
Ditto, with a Nonius Ivory Limb	2	18	0
Ditto, 18 Inches all in Braſs	6	6	0
Ditto, 12 Inches	3	3	0
Davis's Quadrant	0	12	0
Sutton's Quadrant	0	6	6
Caſes of Inſtruments for Drawing in Wood, Braſs, Ivory or Silver, from 10s. 6d. to	26	5	0
Proportional Compaſſes	3	3	0
Ditto, ſmaller	1	11	6
Horizontal Dials, from 10*s.* 6*d.* to	5	5	0
Azimuth Compaſſes			
Common Sea Compaſſes			
Pocket Compaſſes from 5*s.* to	1	1	0
Ring Dials, from 10*s* 6*d.* to	2	2	0
Protractors, from 2*s.* 6*d.* to	1	0	0
Parallel Rulers, Gauging Rods, Gunter's Scales, and all other kinds of Rulers at the uſual Prices.			

Inſtruments invented or improv'd, by Mr. *B. Martin.*

	l.	*s.*	
A new manual Orrery	2	12	0
Planetarium ſhewing the Phænomena of the Ptolemaic and Copernican Syſtem, from 5*l.* 5*s.* to	22	1	0
Lunarium	5	5	0
Ditto, for Jupiter's Moons	5	5	0
A new Portable Air-Pump	6	6	0
Ditto, ſmaller	4	4	0
Barometer, Thermometer, and Hydrometer, all in one Frame	2	12	6
Ditto	2	2	0
Hydroſtatic Balance, from 12*s.* 6*d.* to	2	12	6
Eng. Dogen, or Money Stilyard	0	8	0
A new and moſt accurate Hydrometer	1	11	6
A reflecting Teleſcope, Microſcope, and Megalaſcope, all in one Shagreen Caſe	4	14	6
A new univerſal compound Microſcope, all in Braſs, Shagreen Caſe	4	14	6
A Pocket Compound Microſcope	1	7	0
Ditto, plain	1	1	0
Solar Microſcope in Braſs and Wood	2	12	6
Megalaſcope for magnifying large Objects	1	1	0
A Pocket Perſpective, for viewing Prints	0	12	6
A new Proportional Camera Obſcura, with a Solar Microſcope	2	12	6
Opera Glaſſes of a new and commodious form			
A new Aſtronomical Azimuth Quadrant, all in Braſs	6	6	0
Ditto, in Wood	2	2	0
A new Horizontal Dial for all Latitudes, from 50 to 60 Degrees	2	2	0
Ditto, with Agate Needle and Azimuth Circle	2	13	6
A new Protractor, with Nonius's Diviſions	1	11	6
A Portable Optical Apparatus, conſiſting of a Scioptric Ball and Socket, a Solar Microſcope, Wilſon's Microſcope, a Pocket compound Microſcope, a Pocket Teleſcope and Solar Teleſcope	2	12	6
Ditto, in ſpotted Fiſh-ſkin and Braſs	3	13	6
Ditto, of a large ſize and plain	5	5	0
Ditto, large in Braſs, and true Shagreen	7	7	0
Viſual Glaſſes or Spectacles of a new Conſtruction			
Beſt ſort in Temple frames	0	5	6
Noſe Ditto	0	2	6
Ditto with the beſt Pebbles, in Temple frames	0	16	0

N. B. Very good Allowance will be made to Merchants and others who ſell again, as he deals for ready Money.

Where may be had the following Views.

1. Synopsis Scientiæ Cælestis, or the Knowledge of the Heavens and Earth diſplay'd, in a large Delineation and Explanation, (1) Of the Solar Syſtem, (2) The Theory of the Earth, (3) Aſtronomical Circles, (4) Chronological Tables, (5) Aſtronomical Tables, (6) Of Solar and Lunar Eclipſes, Price 3s.

2. The *Wonders* of the Cometary World diſplay'd in Five new Views of the Solar Syſtem, in which the moſt remarkable Appearances and Particulars relating to Comets are explain'd, in the moſt Natural and evident manner. Price 2s. 6d.

3. A View of the *Solar Syſtem* with the Elevation of the *Orbit of the Comet* which will next return, repreſenting all its Appearances for any Part of the Year when it ſhall be ſeen. Price 1s. 6d.

4. A View of 17 *Tranſits of the Planet Venus*, over the Face of the Sun, *viz.* from the Year 918 to 2117 incluſive, and Particularly that which next happens in the Year 1761, by which the Parallax and Diſtance of the Sun will be nicely determin'd, and the Dimenſions of the Solar Syſtem accurately aſcertain'd.

BRITISH MUSEUM 21 JY99

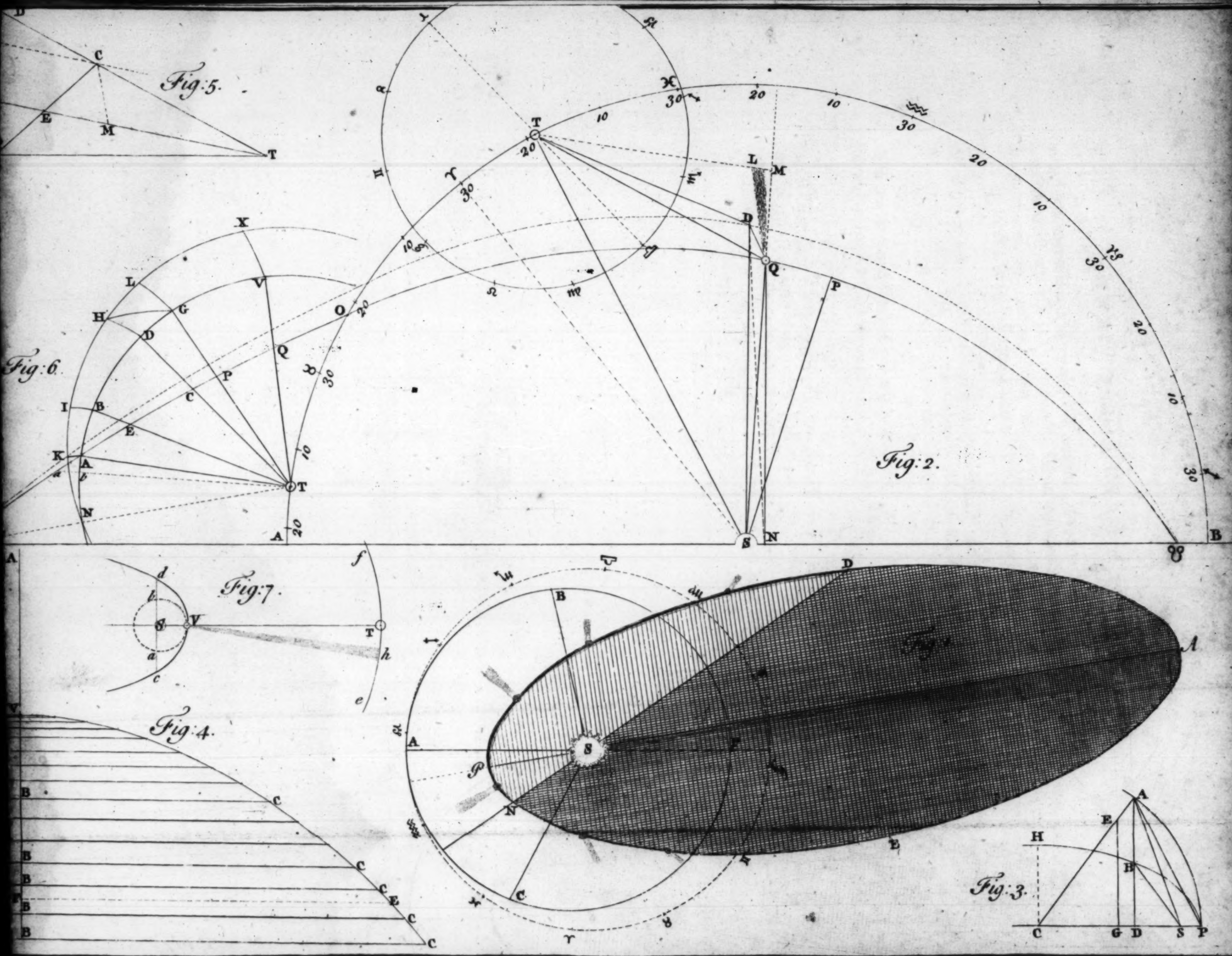
Fig:5.
Fig:6.
Fig:2.
Fig:7.
Fig:4.
Fig:1.
Fig:3.
A
B
C
D
E
F
G
H
I
K
L
M
N
O
P
Q
S
T
V
X
a
b
c
d
e
f
h
10
20
30